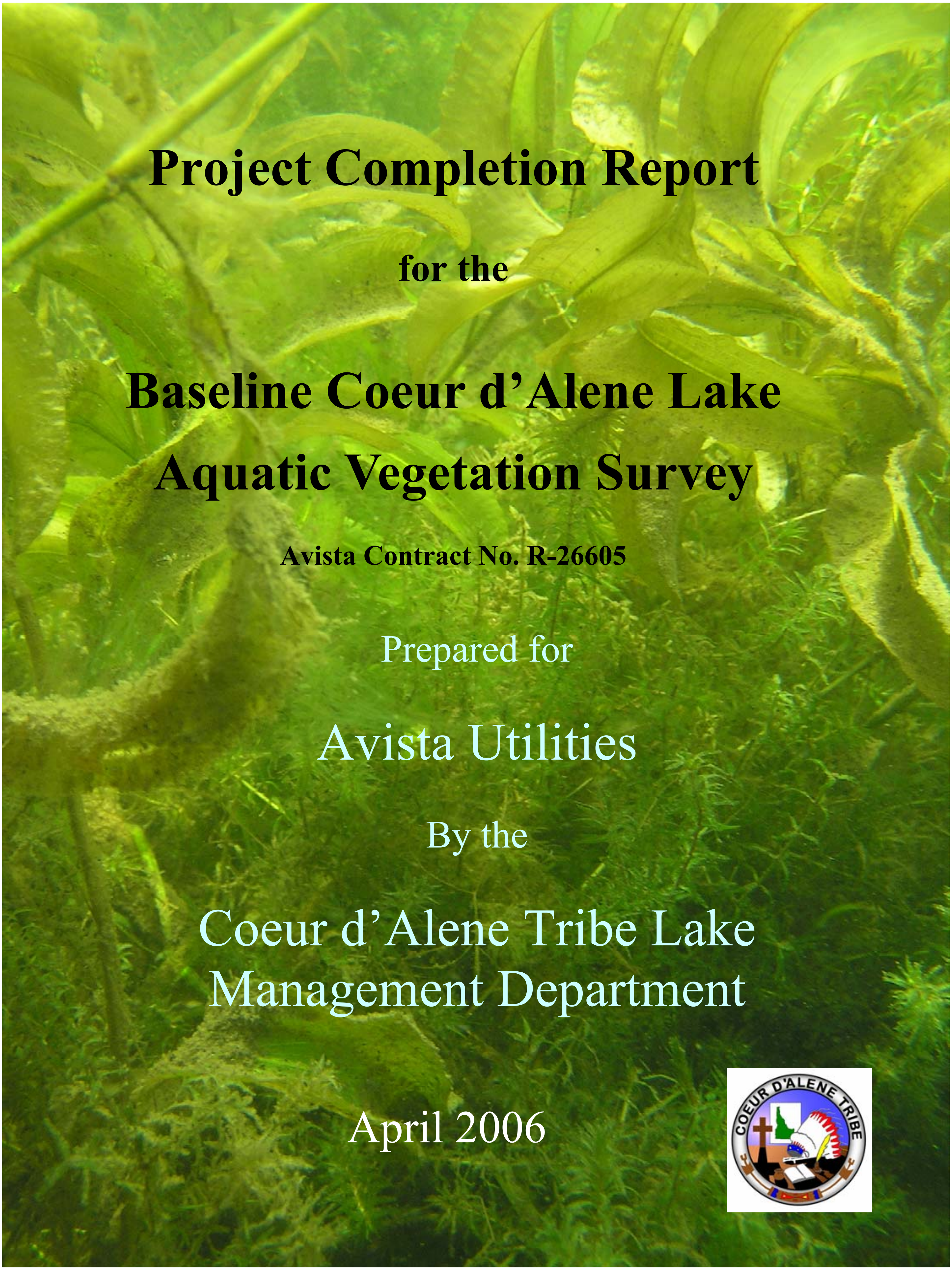

Project Completion Report

for the

Baseline Coeur d'Alene Lake Aquatic Vegetation Survey

Avista Contract No. R-26605

Prepared for

Avista Utilities

By the

Coeur d'Alene Tribe Lake Management Department

April 2006

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April 2006

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Acknowledgements

The Coeur d'Alene Tribe's Lake Management Department wishes to thank Avista Utilities for funding this project. Aquatic vegetation has been largely overlooked in past investigations of Coeur d'Alene Lake and this effort was oriented to filling this void. A parallel project underway by the Tribe is investigating aquatic vegetation in the Lower Lakes area, but the Avista project allowed a more extensive assessment of species presence, biomass and nutrient content across the wider Coeur d'Alene Lake area. It is hoped that the findings of this study, along with those of the Lower Lakes survey, will provide some clarification of certain lake quality questions, and a more holistic understanding of lake management needs.

David S. Lamb, Principal Researcher

Introduction

Avista Corporation is currently involved in relicensing the Post Falls hydroelectric project (referred to as 'Project' herein) with the Federal Energy Regulatory Commission (FERC). Since the operation of this project controls the level (surface elevation) of Coeur d'Alene Lake, it is apparent that its operations impact various conditions in the lake. Several studies have been performed for the relicensing effort which attempted to address concerns over wetlands impacts, erosion and sediment transport, fish populations and habitat and water quality; however, the role of submersed aquatic vegetation is a concern which has not yet been addressed. In August 2004, the Coeur d'Alene Tribe's Water Resources Program submitted a 'Request for Additional Information' asking for a study of submersed aquatic plant population distribution, biomass and nutrient content in Coeur d'Alene Lake. The reason for this request was the Tribe's belief that the Project operations artificially maintain conditions conducive to increased levels (i.e. biomass) of submersed plants and that these plants may be adversely affecting water quality, aquatic communities and Tribal trust resources.

This study has been designed to address existing data gaps on aquatic vegetation present in Coeur d'Alene Lake and, thus, address one of several topics outlined in the Tribe's 'Request for Additional Information'. This study follows sampling and analysis protocols currently in use by the Tribe for the "Lower Lakes Aquatic Vegetation Study", a parallel study funded by the Basin Environmental Improvement Project Commission (Basin Commission) targeting submersed vegetation in Chatcolet, Benewah and Round Lakes.

Throughout this report the terms 'macrophytes', 'aquatic vegetation' and 'aquatic plants' are used interchangeably. What are referred to by each of these terms are those plants which are macroscopic vascular angiosperms (plants having their seeds enclosed in an ovary, as opposed to gymnosperms and algae), and completely submersed (although some may have flowering structures which extend above the water surface). While some forms of macroscopic algae are found in the study area (i.e. *Chara* and *Nitella*), and when found in our samples these were submitted to biomass analysis and their data is included in the summaries herein, these were not a focus of this study.

The proposed study is warranted by the following:

- need for a comprehensive lake-wide database of baseline biomass and species distribution data on which to base water quality modeling efforts, fish habitat assessments, future plant growth assessments and future lake management efforts;
- need for species-specific nutrient (phosphorus and nitrogen) content data to develop estimates of nutrient release (loading) to Coeur d'Alene Lake (this also would affect potential harvesting plans); and
- need for surveillance to document the presence or absence of invasive, noxious aquatic species such as Eurasian watermilfoil.

This study was approved for funding by Avista, through an Agreement for Consulting Services with the Coeur d'Alene Tribe's Lake Management Department, on June 2, 2005. The Avista contract number is R-26605.

Description of Study Area

Coeur d'Alene Lake, Idaho's second largest lake, lies in a naturally-dammed river valley. The Post Falls Project has controlled the lake's water surface level at various elevations since 1906. The Project currently maintains a water surface elevation of 2128 feet during the summer months and allows the lake level to drop to a low elevation of about 2120 during the winter months. Coeur d'Alene Lake is fed by two major rivers, the Coeur d'Alene and the St. Joe, as well as numerous smaller streams. The Coeur d'Alene River watershed covers 1,475 square miles and the St. Joe River watershed covers 1,748 square miles. The combined drainage basin at the Spokane River outlet of Coeur d'Alene Lake is 3,748 square miles.

Following the topography of the near-lake watershed, many of the lake shorelines drop steeply to depth, providing only narrow bands of area suitable for submersed aquatic vegetation growth. There are, however, numerous bays which have expansive shallow areas. In addition, there are extensive areas along the lower portions of the Coeur d'Alene and St. Joe Rivers which are shallow water under current Project operations. With the holding of water levels high during the growing season over the past century, significant areas of historic wetlands and low meadows, primarily in the lower St Joe and Coeur d'Alene River valleys, have been converted to open water with submersed plant growth.

Extensive residential and commercial development of its drainage basin and shoreline, agricultural and silvicultural activities in the watershed plus intensive recreational use of the lake itself, have created concern over the potential for (and rate of) nutrient enrichment. The 1975 National Eutrophication Survey performed by the US EPA determined that Coeur d'Alene Lake was "mesotrophic", or moderately rich in nutrients (US EPA 1977). A more recent study (Woods and Beckwith 1994) found the lake to be "oligotrophic" (low in nutrients) which was indicated to be the result of nutrient loading reductions that occurred within the watershed (particularly the Coeur d'Alene River basin) since the early 1970s. However, the major water quality problem in the lake was the massive amounts of trace elements ("heavy metals") that have been introduced as a consequence of over 100 years of mining and ore processing activities in the upper Coeur d'Alene River basin. Following a study of metals in Coeur d'Alene Lake sediments, Horowitz et al. (1995) estimated that 75 million metric tons of trace element-rich sediments have been deposited on or in the lake bed. While eutrophication and trace metal deposition in the lake may appear to be unrelated water quality problems, both nutrients and trace metals can be released from lakebed sediments (or the rate of release can be increased) if the "hypolimnion" (deep water area) becomes anaerobic as a result of eutrophication. This carries with it the threat of both further water quality degradation and human health / biota risks.

The Woods and Beckwith report describes nutrient load / lake response modeling which determined that the lake has a large capacity for assimilation of nutrients before anoxic conditions would develop in the deeper waters, causing the increased release of both nutrients and heavy metals. Recent monitoring performed by the USGS, however, indicates that nutrient enrichment has been on the rise in recent years thus rekindling the concern for remobilization of trace metals (Beckwith 2005).

The Woods and Beckwith report also includes the description of an assessment of aquatic vegetation in Coeur d'Alene Lake. This was the determination of species presence at 63 sites in the body of Coeur d'Alene and also Chatcolet, and Benewah Lakes. A list of 22 plant genera were found, which included both emergent and submerged species. The genus *Potamogeton* was found to be the most common taxon at the majority of sites. The southern end of the lake was found to have the most extensive plant beds although Cougar Bay at the north end was also heavily populated. Most bays which had extensive sediment deltas also had abundant plant growth.

Purpose / Objectives / Approach

Study Purpose: To develop a baseline description of the submersed aquatic plant community and its potential contribution to nutrient loading in Coeur d'Alene Lake

Study Objectives: Specific objectives of this study were:
1) To describe submersed aquatic plant community composition, density (biomass), and depth distribution in littoral areas of Coeur d'Alene Lake;
2) To describe submersed aquatic plant nutrient composition (total phosphorus and nitrogen) in littoral areas of Coeur d'Alene Lake; and
3) To estimate nutrient loading from the submersed aquatic plant community to open waters of Coeur d'Alene Lake.

Study Approach: Divers using Self Contained Underwater Breathing Apparatus (SCUBA) equipment quantitatively sampled submersed aquatic vegetation on pre-defined underwater transects with quadrats to estimate species composition, biomass, and nutrient composition of the plant community by water depth and location along the Coeur d'Alene lake shoreline. Nutrient composition estimates were coupled with literature-derived nutrient release rates to estimate submersed plant contribution to whole-lake nutrient loading.

Materials and Methods

Sample Collection Techniques

The transect survey was performed during the mid-June to mid-July period in 2005. This timing is about six weeks prior to the maximum annual "standing crop" which typically coincides with the maximum annual water temperature around August 15 in Northern Idaho lakes (Falter 2006). This probably resulted in some underestimation of the role of submersed vegetation in this lake system.

The quantitative sampling was a modification of the "line intercept" method (APHA, 1995). The modification is that samples were collected at set depth intervals along the transects. Samples were collected using SCUBA techniques along fixed lines (transects) which were oriented approximately perpendicular from the shoreline start point. The transect start point coordinates were determined prior to the start of field sample collection using the Tribe's Geographic Information System (GIS) databases so as to obtain samples across all major bay areas around the lake as well as several open shoreline areas. The start points were located in the field using a hand-held Global Positioning System (GPS) unit. At each start point a compass reading was taken perpendicular to the shore and facing the lake, using the diver's compass, and the diver then followed this heading to the maximum depth sampled. Each transect ended at the deepest limit of aquatic plant presence along the respective compass heading.

There were 29 transects sampled as shown on Figure 1. Along these lines, samples were collected at three-foot depth intervals using a "quadrat"; a fixed-corner, three-sided frame that defined a standard sampling area (18 inches square which equals 2.25 square feet or 0.205 square meters). The quadrat is shown in Figure 2 and also Photographs #3 and #4 in Appendix C. At each designated sampling location along the transect line, the quadrat was placed on the lake bottom under and around any plants present and said plants were collected by hand and placed in a mesh bag carried by the diver. The mesh bag was then taken to the surface and given to a boat attendant who would rinse the sample by dipping the mesh bag in the lake water until the rinsate appeared clear, swinging the bag to shake out excess water and transferring the contents to a plastic bag labeled with the date, transect number and depth. Sample bags were placed on ice in a cooler until they were sorted.

At each sampled depth the dominant substrate type was noted by the diver, told to the sample bagger and recorded on the field data sheet. Typical substrate types were "muck" (organic silt), "rocky", "sand" and "clay", with occasional combinations of these.

The depth gauges used for this study were standard diver's equipment and their accuracy was not verified during this study. Because the gauges read only in even feet of depth, it was not always possible for the diver/sampler to exactly locate the sampling depths. As the diver descended along the lake bottom the samples would be collected as soon as the depth gauge read the even foot when placed on the sediment surface; therefore closer to the desired three-foot interval than if the diver was ascending, when the gauge could be up to one foot off the actual depth. The depth gauges also did not work well at depths less than 5 feet so the 18 inch wide quadrat was used to determine the three foot depth. Below five feet the gauges were assumed to be accurate to within one foot.

If the lake bottom along the transect was nearly flat for a long distance (over 150 feet, approximately), or rose and fell so that the three-foot sampling intervals were passed repeatedly, additional samples were collected. These additional samples were labeled with the date-transect-depth and a letter 'b', 'c', 'd' etc to designate the successive samples. The criteria used for when additional samples were collected were a noticeable change in either the plant species assemblage or in the apparent density of the assemblage.

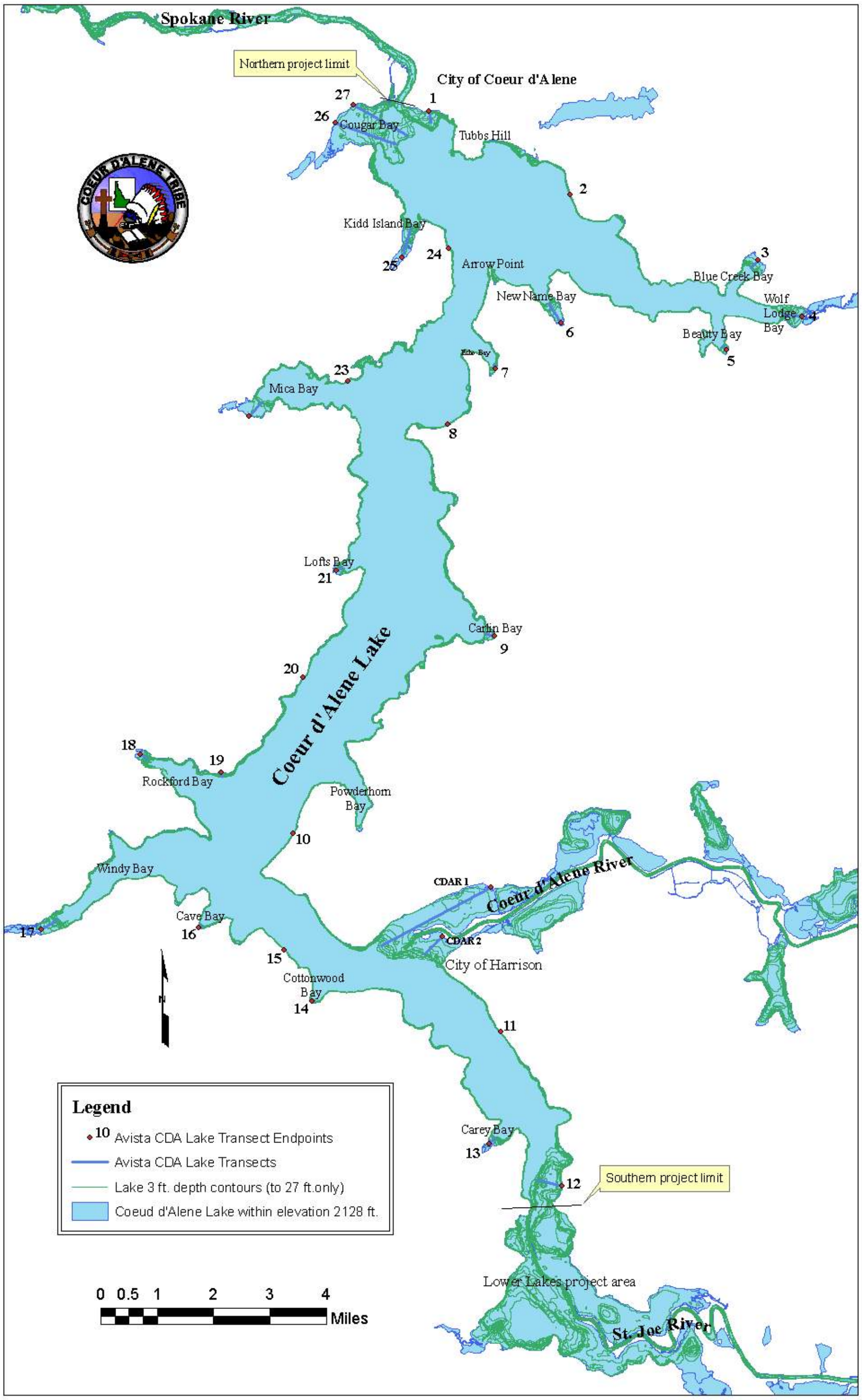

Figure 1. Coeur d'Alene Lake showing aquatic vegetation growth areas and 2005 Baseline Aquatic Vegetation Survey transect locations.

The sampling crew consisted in two certified divers and a boat operator. Typically, only one diver was in the water at a time and the other helped bag and log samples. The boat used for this study was a twin outboard, 24 ft Munson PackCat® landing craft (see Project photographs in Appendix C).

Figure 2. Quadrat and mesh bag used for aquatic vegetation sampling.

Sample Sorting Techniques

At an on-shore location, typically at the Tribe's Natural Resources / Lake Management office building in Plummer, ID, collected plant samples were sorted by project staff within 24 hours of collection. Each bagged sample was placed in a 16 inch by 24 inch by 6 inch deep plastic pan and spread out to separate the biomass as much as possible. As plants were identified they were removed by hand and placed into paper sacks labeled with the date, transect, depth and a three-letter species identifier. Plant samples were sorted to species, whenever possible, or to genus. Two sizes of paper sacks were used (Weyerhaeuser #8 and #420) to accommodate larger or smaller volumes of the sub-samples.

Following the sorting, the paper sacks containing the sorted sub-samples were folded over and stapled to prevent loss of plant material during transport. Bagged sub-samples were placed in topless cardboard boxes and allowed to air dry for between three and five days before delivery to the contract laboratory. This prevented failure of the sacks because of the wetness of the samples (especially large ones) and also may have prevented the growth of mold in the sub-samples prior to laboratory analyses.

Laboratory Analyses

All sorted sub-samples were delivered to Spokane Tribal Labs in Spokane, WA, the selected analytical facility for the previously-initiated Lower Lakes Aquatic Vegetation Survey project. Requested analyses were dry-weight biomass and nitrogen and phosphorus content. All sub-samples and the requested analyses were recorded on Chain-of-Custody forms which were kept on file by both the lab and the Tribe's Principal Researcher. Each Chain-of-Custody form had space to list only 10 sub-samples so the sub-samples for each form were placed together in a grocery sack on which was written a unique identifier which also appeared on the Chain-of-Custody form.

Sub-samples to be analyzed for nutrients were designated by the Tribal Project Lead following sorting of collected samples. Sub-samples were chosen for analyses based on there being a large enough volume of plant material for the analyses (thus these were the larger sub-samples) and on the approximate proportion of the number of sub-samples of each species. Approximately 10% of the sub-samples were designated for nutrient analyses.

Biomass Analyses

The contract laboratory used a modification of Standard Method #10400 D. 3. a. (APHA 1995) to determine Biomass. This involved drying each plant sample sack in a forced-air oven at 105 ºC for 20 – 24 hours, cooling in a desiccator and weighting. Approximately 10% of the sub-samples were dried a second time, cooled and re-weighed as part of the Quality Control procedures (see below and Appendix B). Three batches of paper sacks were used for this study and a selection of 20 sacks from each batch were dried, cooled and weighed twice so that the sack weights could be subtracted from the sack-plus-sample weights. The empty sack weights and the calculated mean weights and standard deviations of the means are also presented in Appendix B. The laboratory reported weights in grams (g) and biomass was calculated by Tribal staff based on the area of the quadrat to yield grams per square meter (g/m^2) biomass.

Total Phosphorus Content

The contract lab followed EPA Method 365.4 to process and analyze collected, dried plant material for phosphorus content. The sub-samples to be analyzed were ground to powder using an "Ultimate Chopper" Model CH-1 food processor. Phosphorus was reported as milligrams phosphorus per dry kilogram of plant (mg/kg).

Total Nitrogen Content

The contract lab followed EPA Methods 351.2 and 300.0 to process and analyze collected, dried plant material for Total Kjeldahl nitrogen (TKN), nitrate (NO_3) and nitrite (NO_2) nitrogen content. TKN is a measure of nitrogen in organic compounds (i.e. plant cell materials) and as ammonia (NH_3)(APHA 1995). Each nitrogen fraction was reported as micrograms nitrogen per dry kilogram plant (mg/kg).

Nutrient Loading Calculations

Nutrients are known to be important in assessing and monitoring water quality, and aquatic vegetation has been shown, in some instances, to influence lake water quality by drawing nutrients (most often phosphorus) from the sediments and recycling them into the open water. Therefore, one of the goals of this project was to estimate potential nutrient (phosphorus and nitrogen) release from the existing plant beds into the water column of this lake. To do this, the baseline survey of species presence, biomass and nutrient contents had to be completed and a literature review had to be performed to obtain information on the processes and rates that nutrients would (or could) be released from the aquatic plant species present in the lake.

The literature review that was performed included a search for published scientific documents related to nutrient release, regeneration or recycling by aquatic plant species. While an initial effort was undertaken utilizing the Internet search engine Google®, most of the effort was focused on searches of natural science databases available through Eastern Washington University and Washington State University. Communications with regional experts in lake management also resulted in a number of document findings. Copies of references found were obtained whenever possible and these were closely studied for pertinent information. While this literature search cannot be considered exhaustive, it did produce a number of helpful documents, most of which were published during the 1970s and 1980s. Further search and procurement of additional (especially more recent) articles would likely allow some refinement of the numerical coefficients used in the nutrient loading estimation.

With the completion of the literature search, aquatic plant species biomass and nutrient data were compiled based on the studied transects. Transect data were expanded to represent a number of "Aquatic Vegetation Regions" in the lake and the area of each of these regions was calculated based on the depths that submersed plants were found along the representative transect(s) for each area. With the area determination (in square meters, m^2), a calculation of lake-wide average biomass for each species (in grams dry weight per square meter, g/m^2) and lake-wide nutrient content for each of the predominant species (in micrograms phosphorus or nitrogen per gram of dry weight biomass) the lake-wide total nutrient content for each species was calculated. This was then applied to the nutrient release criteria obtained from the literature search and the estimated annual release of phosphorus and nitrogen was calculated.

The results of this analysis are presented in the Discussion section, below.

Quality Assurance and Quality Control

Quality assurance and quality control (QA/QC) procedures for this project followed the Quality Assurance Project Plan (QAPP) which was prepared for the Lower Lakes Aquatic Vegetation Survey Project and approved by the Idaho Department of Environmental Quality and the US EPA. QA and QC results specific to this project are summarized in Appendix B.

The quality objective of the Baseline Coeur d'Alene Lake Aquatic Vegetation Survey, like the Lower Lakes Aquatic Vegetation Survey project, is to obtain representative data on aquatic species presence, biomass and nutrient (nitrogen and phosphorus) content. To this end, quality criteria focus on field sampling and sample sorting, laboratory analyses, and data interpretation.

It is important to note that aquatic vegetation growth and distribution is influenced by many factors, including light availability (water clarity and shading are co-factors), water chemistry, sediment texture and composition, depth, slope, disturbances and presence of herbivores. The result of variations in these factors is an often patchy, irregular spatial distribution with varying plant densities of often intermixed species. The presence of invasive species, however, can result in extensive areas occupied exclusively by the invader. With poor water clarity and / or dense plant growth, it is often difficult for someone conducting aquatic vegetation sampling to determine if they are collecting representative samples. Therefore quality criteria for this project focused on the collection of as many samples as possible along with detailed information on depth, location and sediment conditions at the sample sites.

The criterion for field sample collection was to obtain unbiased samples at multiple depths along multiple transects through the study area. Transects were laid out to make maximum use of the project's resources and cover as much of the lake bottom as possible. Divers were trained to closely follow the compass heading of the transect and to find successive sampling depths without regard for the plant species or plant density that might be present.

The criterion for sample processing was the systematic sorting of collected samples by logical, observable characteristics. Characteristics allowed separation by individual species, or by similar groups of species, and each of these became a sub-sample which was submitted for laboratory analysis. Plant species identification followed nomenclature presented in a regional plant manual; in this case *An Aquatic Plant Identification Manual for Washington's Freshwater Plants* (Washington Department of Ecology 2001). Plant identification was performed by or closely overseen by the project lead scientist in order to prevent misidentifications and mis-sorting or mislabeling sub-sample containers. The sorting process retained all plant shoots and leaves but removed all non-plant or non-living material as well as plant roots, rhizomes or other structures found below the sediment surface. Sub-samples were placed in paper sacks clearly marked with the appropriate species identifier, the date collected, the transect number and depth.

The criterion for laboratory analyses was the accurate determination of desired plant characteristics: dry weight and nutrient content. This was accomplished by using an accredited laboratory which followed an approved Quality Assurance Plan. Analytical detection limits, precision and accuracy levels (referred to as Data Quality Indicators) appropriate to this project are presented in Table 1.

The criteria for data interpretation were to use logical organization to tabulate plant biomass data in relation to location, depth, species and nutrient content, and to use accepted statistical analyses to illuminate significant similarities which describe the growth of submersed vegetation across the study area. Because of the typically patchy distribution of aquatic vegetation in the littoral zone of lakes, and the need for "destructive" sampling which removed all vegetation from the sample sites for biomass determination, there are few general Quality Control procedures that apply to this project. As indicated, the quality objective of this project was to obtain representative data on aquatic species presence, biomass and nutrient content. Therefore, quality control in the field focused on sampling and sorting while office procedures focused on methodical, objective data handling.

Table 1. Data Quality Indicators applicable to the Coeur d'Alene Lake Baseline Aquatic Vegetation Survey project.

Parameter	Instrument / Analytical Method	Reporting Units	Detection Limits	Precision	Accuracy	Reference / EPA/Standard Methods
Biomass	Gravimetric	g	0.01 g	+/- 20%	+/- 20%	SM10400 D
Total Phosphorus	Semi-automated Colorimetry	mg/kg	2.50 mg/kg	+/- 20%	+/- 25%	EPA 365.1
Nitrate + Nitrite	Ion Chromatography	mg/kg	1.00 mg/kg	+/- 20%	+/- 10%	EPA 300.0
Total Kjeldahl Nitrogen	Semi-automated Colorimetry	mg/kg	25.0 mg/kg	+/- 20%	+/- 25%	EPA 351.2

Results

Plant Community Structure

In order to describe the observed community structure (mix of plants) seen at the studied transects, an assessment was performed to summarize the species seen at the sampled selected depths lake wide. While this assessment does not account for regional differences, it does provide some insight into the typical assemblages seen.

There were many transects that had no growth at the three-foot depth but where there was growth there was most often two or three species groups present. The most species or species groups seen in a sample was five. *Elodea* species (Esp) and *Potamogeto*n species (Psp, the thin-leafed pondweed species) together were the most frequently encountered with *Sagitaria* species (Ssp, which are believed to be the immature forms of emergent *Sagitaria*) also a frequent addition. Occasionally *P. richardsonii* (PRi) was substituted for 'Esp', although these two were also found together on some transects.

The six foot depth was also most often occupied by two or three species groups but several samples had four. 'Esp' and 'Psp' were most often seen together if there were two groups and 'Esp', 'Psp' and 'PRi' if there were three. The nine foot depth most often had three species or groups but there was no apparent consistency seen in the groupings ('Esp', 'PRi', 'Psp' and 'RA' were the most common species/groups at this depth but two of these was often mixed with *Ceratophyllum demersum* (CD), Isoetes (Iso) or *P. amplifolius* (PA).

At the 12 foot depth the plant assemblage was by far just two species, 'PA' and *P. robinsii* (PR), or the two species groups, 'Esp' and 'Psp'. This depth also had a high number of sample sites with only one species or group, however. And at the 15 foot depth the greatest number of samples had only one species (most often PA), followed by samples with two species groups (Esp and Psp). The 18 foot depth samples most often had two groups, ‘Esp’ and ‘Psp’ and the 21 foot samples were split between one species group, ‘Psp’, and two groups, ‘Esp’ and ‘Psp’.

Biomass Results

All biomass data collected for this study is presented in Appendix A. Note that certain samples delivered to the contract laboratory were returned with a ‘ND’ (Not Detected) dry weight result. These came from the weight of the dried sample plus the paper sack being less than the mean weight of a set of dried empty sacks (i.e. the tare weight). Since these were in fact actual samples a biomass value of 0.01 g/m^2 was assumed for further calculations. This number was selected as a value that would not otherwise be found in the data set but would provide a positive value that could be used in further calculations. The biomass detection limit for the laboratory method is 0.01 g (see Table 1) so the lowest possible aerial biomass value (given that the quadrat sample area is 0.209 m^2) is 0.047 g/m^2. Thus, the value of 0.01 g/m^2 was considered reasonable.

With the type of data collected for this study, many data analyses are possible to show relationships between transect, depth, species, biomass and nutrient content. The data analyses that were performed focused on the calculated means and standard deviations and are therefore not an exhaustive assessment of the data. However, given the quantity of data available and the limited time to complete this summary report, the determination of means and deviations was considered to be a reasonable initial effort. Microsoft Excel® spreadsheet Pivot Tables were used extensively to facilitate review of the data and calculation of the statistical parameters.

Table 2 presents a summary of the transects that were sampled for this study including start point coordinates, compass headings, depth intervals where submersed plants were found and the primary substrate that was noted. Table 3 presents the species codes for the aquatic plants that were found during this study and the corresponding scientific and common names of the plants.

Table 4 presents a summary of the plant species that were found during this study including a listing of the transects where they were found. The overall (lake-wide) mean and standard deviation of the biomass results for each species are also presented, along with the maximum and minimum biomass values. In this table, ‘n’ indicates the number of samples that the species appeared in (which is the basis for the standard deviation calculation). From Table 4, a perspective of the range of densities that these species were found at and also the variation in these densities becomes apparent. The variability of the biomass data is high, as indicated by the high standard deviation values presented (with few exceptions the standard deviation is one to two times the mean value). This is undoubtedly influenced by the fact that the plants are found at locations with widely differing depths, slopes, aspects and substrates.

The two species found at the highest biomass were *Potamogeton amplifolius* (PA) and *P. robinsii* (PR), each having a mean biomass over 60 g/m^2. *P. amplifolius* is one of the largest plants found in these waters (both in terms of height, often growing to 15 ft tall, and overall bulk). *P. robbinsii*, on the other hand grows fairly close to the bottom (typically not more than two feet tall) but grows extremely densely. On the lower end of the observed biomass range are

Table 2. Description of transects sampled during the 2005 Baseline Coeur d'Alene Lake Aquatic Vegetation Survey project.

Transect	Start Point Coordinates*		Compass headings (°)	Depth Interval** where plants found	Primary Substrate
1	515600	5280064	210	6 only	sand / bark
2	519655	5277663	210	9 to 27	muck
3	525031	5275804	210	3 to 18	muck
4	526300	5274168	270	3 to 15	muck
5	524128	5273203	310	6 to 18	muck
6	519406	5273946	315	3 to 24	muck
7	517523	5272683	340	3 to 21	muck
8	516155	5271090	320	(no veg.)	rocky
9	517490	5265022	280	3 to 18	muck
10	511732	5259356	280	(no veg.)	rocky
11	517657	5253666	210	9 to 15	rocky
12	519409	5249256	260	9 to 15	muck
13	517391	5250509	40	3 to 21	muck
14	512237	5254553	15	6 to 21	muck
15	511472	5256006	20	9 to 15	rocky
16	509024	5256658	50	6 to 21	muck
17	504506	5256614	45	3 to 21	muck
18	507316	5261648	90	3 to 18	muck
19	509662	5261104	180	6 to 21	muck
20	512003	5263834	90	(no veg.)	rocky
21	512942	5266897	60	3 to 24	muck
22	510466	5271321	60	3 to 24	muck
23	513284	5272322	130	15 only	rocky
24	516452	5276117	50	6 to 15	rocky
25	514839	5275788	0	3 to 15	muck
26	512912	5279738	90	3 to ? ***	muck
27	513449	5280236	140	3 to ? ***	muck
CDAR 1	517315	5257705	230	3 to 21	muck
CDAR 2	516016	5256337	200	3 to 18	muck

* NAD 1983, UTM Zone 11N ** Feet below normal summer pool water level of 2128 ft.

*** Log storage area blocked access to areas deeper than 6 ft.

Isoetes (Iso) and *Najas* (Nsp) species, both averaging just over 1.0 g/m^2. Both of these species are small plants which grow generally sparsely. Four of the collected species were found at individual maximum biomass levels around 300 g/m^2; *Ceratophyllum demersum* (CD), *Elodea* species (Esp), 'PR' and the thin-leafed *Potamogeton* species (Psp). 'Esp' and 'Psp' are the two most frequently encountered species, as indicated by the ‘n’ values presented in Table 4. While found in only seven samples from three transects, the species group *Myriophyllum* species (Msp) is noteworthy because it includes the invasive aquatic species *M. spicatum*, Eurasian watermilfoil. This species is found to be widespread in the Lower Lakes area, from which it is expected to spread rapidly if not controlled. These seven samples are certainly an underestimation of its presence in Coeur d’Alene Lake.

The biomass data compiled by transect (all species and depths) is presented in Table 5 and Figure 3. The highest average biomass was 67.9 g/m^2 seen at Transect 26 (Cougar Bay) although Transects 3, 7 and 12 (Blue Creek Bay, Echo Bay and the south end, respectively) all had averages greater than 40 g/m^2. (It should be noted that Transects 26 and 27, both of which are in Cougar Bay could only be partially sampled due to the presence of an extensive log storage area which prevented diver and boat access to areas deeper than six feet.) Three transects, numbers 8, 10 and 20 (all steeply sloping shoreline areas) had no vegetation. Again, the high standard deviations calculated indicate the high degree of variability in this summarization.

Table 3. Species codes and scientific and common names of plants sampled during the 2005 Baseline Coeur d’Alene Lake Aquatic Vegetation Survey project.

Species Code	Scientific and common names
CD	*Ceratophyllum demersum* (Coontail)
Cha	*Chara* (Muskgrass; macroalgae)
Esp	*Elodea* species (Waterweed, mostly *E. canadensis*, some *E. nuttallii*)
Iso	*Isoetes* species (Quillworts)
Msp	*Myriophyllum* species (primarily *M. spicatum*, Eurasian watermilfoil)
Nit	*Nitella* (macroalgae)
Nsp	*Najas* species (Water-Nymph or Nyad)
PA	*Potamogeton amplifolius* (Large Leafed Pondweed)
PF	*Potamogeton friesii* (Flat stalked Pondweed)
PP	*Potamogeton praelongis* (White Stemmed pondweed)
PR	*Potamogeton robbinsii* (Fernleaf Pondweed)
PRi	*Potamogeton richardsonii* (Richardson's pondweed)
Psp	*Potamogeton* species (undifferentiated thin leafed Pondweeds)
PZ	*Potamogeton zosteriformis* (Flat Stem Pondweed)
RA	*Ranunculus aquatilis* (White Water Buttercup)
Ssp	*Sagitaria* species (likely immature forms of emergent plants)
VA	*Vallisnaria americana* (Tapegrass, water celery)
UNK	Unknown, unidentified plants

Table 4. Summary of submersed aquatic vegetation sampled during the 2005 Baseline Coeur d'Alene Lake Aquatic Vegetation Survey project.

Species Code	Transects where species was found	Overall Mean Biomass (g/m^2)	Standard Deviation	n	Maximum Biomass (g/m^2)	Minimum Biomass (g/m^2)
CD	12, 21, 22, CDAR1	43.99	87.47	16	299.52	0.24
Cha	3, 4, 5, 7, 9, 18, 21	8.67	11.66	10	30.77	0.01 *
Esp	2, 3, 4, 5, 6, 7, 8, 9, 12, 13, 14, 15, 16, 17, 18, 19, 21, 22, 23, 24, 25, 26, 27, CDAR1, CDAR2	27.76	59.63	82	331.58	0.01 *
Iso	2, 3, 4, 15, 16, 18, 19, 27	1.23	1.33	8	3.92	0.01 *
Msp	11, 12, CDAR1	18.92	16.25	7	41.34	2.73
Nit	3, 6, 7, 9, 12, 16, 18, 19, 21, 22, 25, 26, 27, CDAR1, CDAR2	7.32	15.12	33	82.78	
Nsp	3, 6	1.1	0.34	2	1.34	0.86
PA	3, 4, 5, 6, 7, 9, 19, 25	65.72	54.79	21	190.91	5.79
PF	11, 17, 18, CDAR1	16.26	16.96	7	44.55	3.25
PR	2, 5, 6, 7, 9, 11, 12, 18, 19, 22, 24, 25, CDAR1	62.59	77.36	32	329.19	0.53
PRi	2, 3, 4, 6, 7, 9, 12, 14, 16, 17, 18, 19, 21, 22, 24, 25, CDAR1, CDAR2	26.45	27.85	41	140.67	0.86
Psp	1, 2, 3, 4, 5, 6, 7, 9, 12, 13, 14, 15, 16, 17, 18, 19, 21, 22 ,24, 25, 26, 27, CDAR1, CDAR2	33.43	50.97	92	285.17	0.01 *
PZ	13, 14, CDAR1	7.03	5.3	4	14.4	2.63
RA	2, 3, 5, 6, 12, 13, 15, 16, 19, 22, 24, 27	4.62	6.07	20	25.89	0.01 *
Ssp	6, 7, 9, 13, 14, 17, 18, 19, 21	5.27	3.99	13	14.98	1.96
UNK	21, 26	nc	nc	nc	nc	nc
VA	12, CDAR1	10.77	10.85	3	23.11	2.73

nc = not calculated * 0.01 is the arbitrary value assigned when the lab reported a ND (non-detect) for sub-samples.

Table 5. Summarized aquatic vegetation biomass statistics for transects sampled during the 2005 Baseline Coeur d'Alene Lake Aquatic Vegetation Survey project.

Transect	Overall Mean Biomass (g/m^2)	Standard Deviation	n	Maximum Biomass (g/m^2)	Minimum Biomass (g/m^2)
1	0.5	0.0	1	0.5	0.48
2	25.9	40.3	15	138.3	0.01
3	53.8	98.2	14	329.7	0.19
4	31.2	56.6	13	167.0	0.01
5	19.4	31.0	9	94.3	0.48
6	36.2	54.9	23	190.9	0.01
7	49.1	76.2	22	329.2	0.01
8	0		0	0	0
9	31.7	58.7	19	207.7	0.05
10	0		0	0	0
11	5.5	1.4	3	6.4	3.90
12	48.8	86.8	33	331.6	1.63
13	18.4	25.2	16	79.4	1.63
14	8.9	10.5	16	36.0	1.20
15	1.9	1.6	7	4.9	0.14
16	15.6	16.0	21	63.6	0.62
17	28.0	48.3	21	182.3	1.48
18	24.4	29.3	25	115.8	0.19
19	13.7	20.1	20	80.4	0.48
20	0		0	0	0
21	20.7	28.5	21	98.1	0.19
22	20.3	31.7	25	150.2	0.01
23	1.0	0.0	1	1.0	0.96
24	3.8	3.7	9	11.9	0.77
25	27.8	27.3	11	73.2	0.14
26	67.9	76.3	6	179.9	1.87
27	20.1	29.9	5	70.3	0.01
CDAR-1	39.4	61.9	23	285.2	1.72
CDAR-2	38.3	53.1	14	163.6	1.24

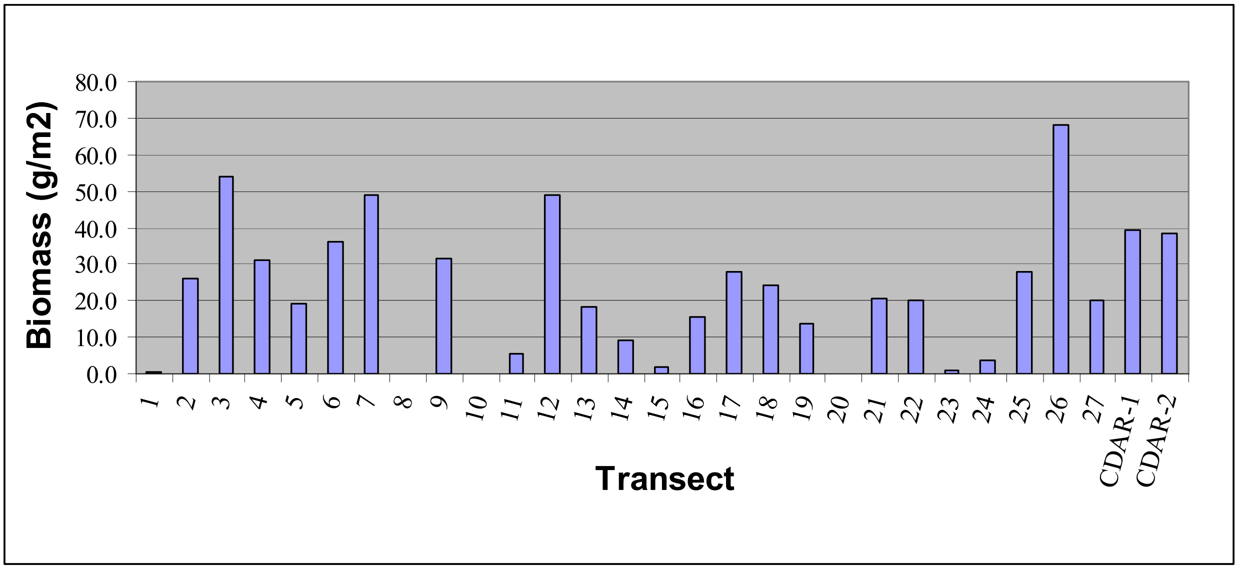

Figure 3. Average aquatic vegetation biomass variations (all species) by transect in Coeur d'Alene Lake, 2005.

Aquatic vegetation summarized by depth (across all transects and species) is shown in Table 6 and Figure 4. These indicate that submersed plants were found at depths between three and 27 feet, although there were few sites that had any vegetation at the 24 or 27 foot depths. In fact, from Table 2, Transect 2 was the only one with vegetation to 27 feet and transects 6, 21 and 22 were the only others that had plants to 24 feet. As indicated in Figure 1, these transects with deeper growth are all in the northern half of Coeur d'Alene Lake, where the water is noticeably clearer.

Table 6. Summarized aquatic vegetation biomass by depth for all transects sampled during the 2005 Baseline Coeur d'Alene Lake Aquatic Vegetation Survey project.

DEPTH	Overall Mean Biomass (g/m^2)	Standard Deviation	n	Maximum Biomass (g/m^2)	Minimum Biomass (g/m^2)
0	0		0	0	0
3	29.21	48.08	63	285.17	0.01
6	23.64	37.46	76	215.79	0.01
9	34.53	68.32	87	331.6	0.01
12	44.16	70.93	54	329.19	0.01
15	23.18	35.9	51	146.89	0.01
18	22.09	33.48	36	138.28	0.05
21	15.04	23.47	19	100.96	0.01
24	9.42	13.86	6	34.4	0.014
27	7.56	0	1	7.56	7.56

The highest biomass average (44.16 g/m^2) was seen at the 12 foot depth. Except for the slightly elevated mean biomass at the three foot depth (or a slightly depressed biomass at six feet), the means form a bell-shaped curve on either side of the 12 foot depth. The reason for the anomaly at three and/or six feet is not apparent, although it may be a result of the calculation of mean biomass being only of sites that actually had some vegetation present (which does not consider locations that had no vegetation, which was the case at the three foot depth on quite a few transects).

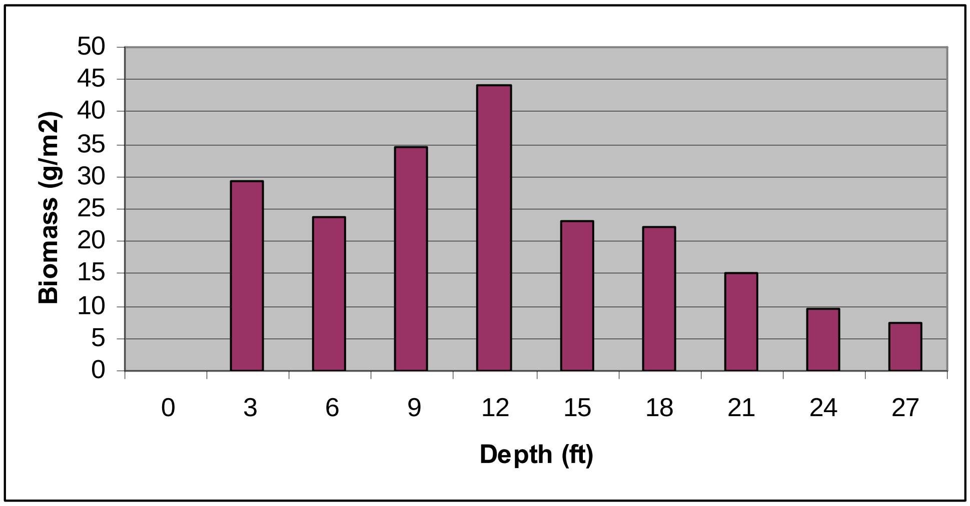

Figure 4. Aquatic vegetation biomass variations by depth for all transects sampled in Coeur d'Alene Lake, 2005.

Nutrient Results

All aquatic vegetation nutrient content results are presented in Appendix A. Nutrient analyses were only performed on the seven predominant species collected from the sampled transects. These species were *Ceratophyllum demersum* (CD), *Elodea* species (Esp), *Potamogeton amplifolius* (PA), *P. friesii* (PF), *P. robinsii* (PR), *P. richardsonii* (PRi) and the thin-leafed *Potamogeton* species (Psp).

Tables 7 through 10 present the averages, standard deviations, maximum and minimum values of the four analyses that were performed on the samples. These analyses were total phosphorus (TP), total Kjeldahl nitrogen (TKN), nitrate nitrogen (NO_3) and nitrite nitrogen (NO_2), as described in the Methods section, above. The overall average and standard deviation, that is of all samples of each species (regardless of transect or depth) is the only summarization performed on this data. This is due to there being too few nutrient results to assess nutrient content by transect or depth. However, it can be seen in Tables 7 through 10 that the variability is considerably less than that of the biomass data.

The TP summarization shown in Table 7 indicates that Esp contained the highest concentration of phosphorus, with a mean of 4,738 µg P/g. CD and Psp were also over 4,000 µg P/g, however.

The lowest mean phosphorus concentration of the plants analyzed was 2,975 µg P/g in PR The maximum TP concentration reported was 6,050 µg P/g, again in Esp, while the lowest was 2,180 µg P/g in PRi.

Table 7. Total phosphorus (TP) data collected for the 2005 Baseline Coeur d'Alene Lake Aquatic Vegetation Survey project.

Species Code	Overall Mean TP (µg/g)	Standard Deviation	n	Maximum TP (µg/g)	Minimum TP (µg/g)
CD	4,670	918	3	5,200	3,610
Esp	4,738	1,301	5	6,060	3,080
PA	3,555	1,151	6	5,500	2,450
PF	3,120	0	1	3,120	3,120
PR	2,975	682	6	4,330	2,560
PRi	3,970	1,124	8	5,540	2,180
Psp	4,330	535	7	4,970	3,540

The organic forms of nitrogen (including ammonium), as measured by the Total Kjeldahl nitrogen analysis, were by far the predominant forms of nitrogen in all of the vegetation samples (Table 8). Of special note is the similarity in TKN results across the species tested. The highest mean TKN (25,457 µg N/g) was seen with the Psp and the lowest (21,000 µg N/g) was with PA. The maximum value found was 27,400 µg N/g with Psp and the minimum was 13,600 with Esp.

Table 8. Total Kjeldahl nitrogen (TKN) data collected for the 2005 Baseline Coeur d'Alene Lake Aquatic Vegetation Survey project.

Species Code	Overall Mean TKN (µg/g)	Standard Deviation	n	Maximum TKN (µg/g)	Minimum TKN (µg/g)
CD	23,133	306	3	23,400	22,800
Esp	21,860	5,346	5	26,500	13,600
PA	21,000	3,778	6	23,900	14,100
PF	26,000	0	1	26,000	26,000
PR	24,033	2,827	6	26,400	19,500
PRi	22,750	3,592	8	26,200	14,800
Psp	25,457	2,062	7	27,400	22,000

The nitrate concentration data, while only a fraction of the TKN concentrations, appeared to be quite variable across the species tested (Table 9). The highest mean was 35.8 µg N/g for PR and the lowest mean was 3.6 µg N/g for Esp. Interestingly, both the maximum and minimum values were found with PA; ranging two orders of magnitude, from 77.6 µg N/g to 0.7 µg N/g. Both the high and low outliers indicated in the data set (appendix A) were deleted from the mean and deviation calculations.

Table 9. Nitrate nitrogen (NO_3) data collected for the 2005 Baseline Coeur d'Alene Lake Aquatic Vegetation Survey project.

Species Code	Overall Mean NO_3 (µg/g)	Standard Deviation	n	Maximum NO_3 (µg/g)	Minimum NO_3 (µg/g)
CD	28.7	12.0	3	39.1	15.6
Esp	3.6	2.1	5	6.8	1.0
PA	24.3	28.7	6	77.6	0.7
PF	25.0	0	1	25.0	25.0
PR	35.8	12.2	5 *	54.2	21.5
Pri	35.4	67.7	8 **	21.6	2.6
Psp	7.4	5.1	7	13.8	1.5

* omitting one < 0.5 value ** omitting high of 202

As can be seen in Table 10, nitrite was below the analytical detection limit in almost all of the samples tested.

Table 10. Nitrite nitrogen (NO_2) data collected for the 2005 Baseline Coeur d'Alene Lake Aquatic Vegetation Survey project.

Species Code	Overall Mean NO_2 (µg/g)	Standard Deviation	n	Maximum NO_2 (µg/g)	Minimum NO_2 (µg/g)
CD	< 0.5	*	3	< 0.5	< 0.5
Esp	< 0.5	*	5	< 0.5	< 0.5
PA	< 0.5	*	6	< 0.5	< 0.5
PF	5.8	*	1	5.8	5.8
PR	**	*	6	11.8	< 0.5
PRi	< 0.5	*	8	< 0.5	< 0.5
Psp	< 0.5	*	7	< 0.5	< 0.5

* not calculated ** four of six results were < 0.5

QC Results

Duplicates

Biomass

Biomass QC results are presented in Table B1 in Appendix B in the form of duplicate tests. A total of 40 samples (10% of the total number of sub-samples analyzed) were re-dried, cooled and re-weighed to test the precision of the drying and weighing process. The comparison of initial and duplicate results is presented as the "Relative Percent Difference" (RPD). From the lab's QAP, RPD is calculated as follows:

$$RPD = \frac{(\text{original result} - \text{duplicate result})}{(\text{original result} + \text{duplicate result})/2} \text{ X } 100$$

The confidence limit (RPDCL) for this is 20% and all but five samples were well within this limit. In fact, the mean RPD of those results that were within the RPDCL was 2.91 with a standard deviation of 3.54. The five samples that were not within the RPDCL were less than ten times the Reporting Limit (0.1 gram); i.e. very low biomass levels.

Nutrients

Duplicate nutrient QC results are presented in Table B2 in Appendix B. Three samples for each of four analyses [Total Phosphorus (TP), Total Kjeldahl Nitrogen (TKN), Nitrate and Nitrite) were duplicated in order to test the precision of the nutrient analyses. Again, Relative Percent Difference was determined from the initial and duplicate results. In the case of TP and TKN, which have a RPDCL of 25%, all duplicate results were within this limit. Specific mean ± standard deviation of RPD values were 8.87 ± 7.26 for TP (actual range 3.88 – 17.2) and 1.16 ± 0.70 for TKN (actual range 0.40 – 1.78). Nitrate RDPCL is 20% and, again, all duplicate results were within this limit (RPD mean value of 2.81 ± 2.51, actual range 1.03 – 6.67). All nitrite results were below the analytical detection limit of 0.5 mg/kg so no RPDs were calculated.

Nutrient Matrix Spikes

To test the accuracy of the nutrient analyses, spikes of known concentration were added to certain sample digestates and analyses were re-run (see Table B3 in Appendix B). For TP the spikes were 1,000 and 2,000 mg/kg, for TKN they were 1,000, 2,000 and 5,000 mg/kg and for nitrate and nitrite the spikes were 100 mg/kg. QC results were based on the percent recovery of the combined sample plus spike and the applicable confidence limits are 80 – 120% of the expected result. Actual percent recovery determined for this analysis was 86% – 105% for the TP testing, 82% – 105% for TKN, 80 – 100% for nitrate and 70 – 77% for nitrite. Therefore all matrix spike results were within the required confidence limits except for nitrite. The reason for the nitrite spike failure was indicated by the lab to be due to "matrix interference". This was the result of higher chloride levels in the samples which interfered with the nitrite peak on the ion chromatograph printout.

Nutrient Reference Samples

Nutrient reference analysis results are presented in Table B4 in Appendix B. Analysis of reference materials of known nutrient concentrations was performed to provide an important indication of method accuracy. In this case analytical standard apple leaves were purchased and put through the various nutrient tests. Analytical results were compared to the reference (known) concentration and a percent recovery was determined. Overall the recovery percent ranged from 85% - 114% for TP, TKN and nitrate. The applicable confidence limits were between 75% and 125% for TP and TKN and between 77.4% and 122.6% for nitrate. Thus, all tests were within the prescribed confidence limits.

Nutrient Blanks

Nutrient blank analysis results are presented in Table B5 in Appendix B. The contract laboratory checked blank samples for the presence of contaminants in the dilution water and reagents. All blank tests came back below detection so it can be said that there was no contamination above the detection limits.

Empty Sack Weights

The paper sacks used for the sub-samples were found to lose some weight and also to have a lower standard deviation following the drying process. The first batch of #8 sacks (printed with black ink) started with a mean weight of 10.879 ± 0.040 g and ended with a mean of 10.313 ± 0.035 g, or a loss of 0.57 g on average. The second batch of #8 sacks (printed in red ink) started with a mean of 10.456 ± 0.084 g and ended at 9.935 ± 0.064 g, or a 0.52 g loss. The single batch of #420 sacks started with a mean weight of 21.924 ± 6.748 g and lost approximately 2.62 g to end with a mean of 19.305 ± 0.1160 g. Again, the mean weights of the dried sacks were subtracted from the sack-plus-sample weights to obtain the weight of the sample only.

Discussion

Comparison of Project Results with Those of Other Studies

Biomass

Since the studies described in the literature searched for the nutrient release information were often conducted in-situ in lakes, or using vegetation collected from lakes, it is possible to compare the findings of the present study with other efforts. From the Results section above, the highest biomass recorded for this project was 331.58 g/m^2 from an Esp (Elodea species) sample and the mean biomass ranged from 65.72 g/m^2 to 1.1 g/m^2.

Soltero, et al. (1988) performed a water quality assessment on the euthrophic Eloika Lake, Spokane County, WA, and reported the following mean, above-sediment biomass data: *C. demersum* 730 g/m^2, *E. canadensis*, 750 g/m^2, *P. robbinsii*, 10,380 g/m^2 and *P. praelongis* 4,420 g/m^2. In other words, up to three orders of magnitude higher than the Coeur d'Alene Lake results. Chambers and Prepas (1994) characterized the nutrient pool of a Canadian riverbed also indicated that rooted aquatic plants could achieve biomasses greater than 1,000 g/m^2 (although no species were listed and it was not made clear if this was above-sediment biomass only).

In contrast to the above, Smith and Adams (1986) reported mean shoot biomass of *Myriophyllum spicatum* to be approximately 225 g/m^2 as a seasonal maximum in Lake Wingra, WI. Similarly, James et al. (2001) studied *P. crispus* in Half Moon Lake, Eau Claire, WI, and indicated a lakewide June biomass of 31.1 g/m^2 (Note that *P. crispus* was not found in Coeur d'Alene Lake but this species senesces in July so the June results approximate seasonal maximum. It was also not clear from the study methods if this biomass was above-sediment only. This is presented here for perspective only). Filbin and Barko (1985) studied growth and nutrition of macrophytes in Eau Galle Reservoir, WI and showed that the mean seasonal maximum above-sediment biomass was approximately 300 g/m^2 and was comprised primarily of *C. demersum* and *P. pectinatus*. Finally, Funk et al (1982) performed a preliminary assessment of the effectiveness of restoration measures at Liberty Lake, Spokane County, WA, and reported maximum, above sediment standing crop (all species) of between 32 g/m^2 and 257 g/m^2 at various depths in the southern end of that lake.

Thus, it appears that the findings of this project in Coeur d'Alene Lake are within the range of biomasses seen elsewhere in North America and considerably less than those in euthrophic waters.

Nutrient Content

As far as nutrient content goes, fewer studies present pertinent comparisons of the phosphorus content of submersed plant species. No comparative data on total nitrogen concentrations was found in the available literature. Again, from the analysis above, the mean TP content ranged from 4,738 µg/g for Esp to 2,975 µg/g for PR.

Carignan and Kalff (1982) analyzed a number of species and reported a wide range of TP concentrations in Lake Memphremagog, Quebec. *P. richardsonii* was the highest at 5,020 µg/g (only one sample) while *E. canadensis* had a mean of 2,870 µg/g, *P. zosteriformis* had a mean of 3,160 µg/g and *M. spicatum* had a mean of 2,500 µg/g. Barko and Smart (1980) reported 3,400 µg/g for *M. spicatum* in greenhouse-cultured plants.

Thus, it appears that the findings of this project in Coeur d'Alene Lake are within the range of phosphorus concentration seen elsewhere.

Literature Review of Potential Nutrient Release from Macrophytes

Overview

The role of macrophytes in the spatial structure and physical-chemical properties of shallow, littoral waters in lakes is widely discussed in the scientific literature (Hutchinson 1975, Wetzel 1975, Jeppesen et al. 1997). Macrophytes are also known to be important in the regulation and cycling of minerals and organic compounds in water bodies (Cooke et al. 2005). Phosphorus is the element that is often identified as the "limiting nutrient" for macrophyte and algae growth (Vollenweider 1970) and since macrophytes may account for a significant fraction of the plant biomass in lakes, it stands to reason that macrophyte nutrition may influence lake-wide phosphorus budgets.

It is now recognized that sediment composition exerts an important influence on macrophyte productivity and species composition; however the mechanisms involved are complex (Barko et al. 1991). Lake sediments are reservoirs of nutrients which can be tapped by aquatic macrophytes (Wetzel 1975). Inorganic silt and organic matter are continually accumulated on lake bottoms through the physical settling of suspended material. Both silt and organic matter (plant / algae and animal remains) can bring nutrients to the sediments. Although some of the nutrients incorporated into the sediments may be returned to the overlying water through physical and chemical mechanisms (especially low oxygen and/or high pH conditions in overlying water), most remain there in forms exploitable by aquatic macrophytes. The anoxic, reduced nature of most sediments, typically beneath an oxidized microzone (Barko and James 1998), promotes high solubility of phosphorus and other nutrients (Barko and Smart 1980).

Researchers have long debated the relative importance of macrophyte leaves versus roots as primary areas of nutrient uptake (and water versus sediment as primary sources of nutrients). This is an important question related to lake-wide nutrient budgets because macrophytes could be considered as nutrient pumps (i.e. nutrients obtained primarily through the roots and translocated to the leaves during growth) or nutrient sinks (i.e. nutrients absorbed by leaves and stems and thus removed from the water). Early studies seemed to point to roots as primarily attachments to the substrate (Wetzel 1975) but more recent literature supports the view that roots are also the main sites of uptake, at least for nitrogen and phosphorus (Barko and Smart 1980, Smith and Adams 1986).

The question of water versus sediment as the primary source of phosphorus for macrophytes appears to be put to rest with the findings of Carignan and Kalff (1980) that in both oligotrophic and mildly euthrophic lakes, characterized by relatively high interstitial phosphorus concentrations in the sediments, the sediments constitute the only significant source of phosphorus to rooted plants. Only in rarely encountered hypereutrophic (highly productive) waters is there significant phosphorus uptake from the water. Therefore the relative contribution from water and sediment appears to be a function of their relative phosphorus availability. The pore waters of sediments can be 9 to 600 times richer in phosphorus than the water and thus rooted macrophytes normally obtain about 85% of the P required for growth directly from the interstitial soil pore water (Carignan and Kalff, 1980).

Information on the relative contribution to the nitrogen needed for submersed plant growth is quite limited in comparison to that available for phosphorus. Experiments utilizing the radioisotope ^{15}N and *Myriophyllum spicatum* demonstrated that this element can be supplied readily from both water and sediment (Nichols and Keeney, 1976). These experiments also indicated that uptake rates were proportional to the nitrogen concentration in the respective water or sediment and that the subject plant species preferred ammonium (NH_3) over nitrate (NO_3) as the form of nitrogen utilized. Given that ammonium, like phosphorus, is usually in much lower concentrations in the open water, the sediments can be inferred to be the primary source of nitrogen.

While the uptake of nutrients by macrophytes has been fairly well determined, the subsequent release of those plant constituents has not. The following discussion presents a summary of available published information on nutrient release from aquatic vegetation, particularly resulting from three primary processes: release from healthy, growing plants, release from materials sloughed from plants during growth and release during plant senescence. The role of algae attached to macrophytes ("epiphytes") is also mentioned.

Macrophyte shoot decay rates depend on several environmental factors, notably temperature, oxygen concentration, nutrient concentrations and chemical composition of the decomposing tissue (Carpenter, 1980). These factors were not determined for this study. The early stages of decay when the plant shoots are still standing in the water column are most relevant to nutrient loading. Not only are large amounts of phosphorus released during the initial states of degradation (Nichols and Keeney, 1976) but there is less chance that these nutrients will be absorbed (and/or adsorbed) by the sediments (Carpenter, 1980). However, collapsed macrophytes decaying at the sediment surface may lower the redox potential through consumption of available oxygen and thereby enhance diffusion of nutrients from the sediments (Carpenter, 1980). Analyzing this potential, though, was beyond the scope of this project.

Phosphorus Release

Phosphorus Release from Growing Plants

The scientific literature provides conflicting evidence of excretion of phosphorus by actively growing, rooted aquatic plants. Of those reporting losses to water, few gave estimates of release rates or percentages of cellular nutrients that would or could be released. Differences in study results may be due to experimental conditions or to differences between species. For instance, Carignan and Kalff (1982) found that transfer of phosphorus from nine species of macrophytes (including *E. canadensis*, *M. spicatum*, *P. richardsonii* and *P. zosteriformis*) to epiphytes was minimal. Unfortunately most of this work was on *M. spicatum*, which is not yet a significant component of the Coeur d'Alene Lake plant community. Similarly, Barko and Smart (1982) tested *Hydrilla verticulata*, *Egeria densa* and *M. spicatum* (all invasive, noxious weeds) and found that cumulative phosphorus released from plant shoots represented less than 10% of the total P mobilized from the sediments. Welsh and Denny (1979, described in Gabrielson et al.

1984) found translocation of phosphorus from roots to shoots and shoots to roots but negligible excretion in *Potamogeton*.

In contrast, Moore et al (1984) used sediments and *E. canadensis* form Liberty Lake, WA and found that the loss of phosphorus from plants in a laboratory experiment was 25 µg P/gram/day (assumed to be grams dry weight basis). A previous study by Moore (1981) reported an average of 58 mg P/gram dry weight/day which is substantially higher. These findings are corroborated, in general, by Wallsten (1980, described in Gabrielson et al 1984) that *E. canadensis* translocated "large amounts" of phosphorus from roots to foliage with subsequent release to water.

For the present study, phosphorus release from growing plants is assumed to be negligible except with *E. canadensis*, for which a release rate of 25 µg P/gram/day (9 mg P/g/year) is used for the nutrient loading calculation.

Phosphorus Release from Sloughed Plant Fragments

Another factor that can affect potential nutrient release from macrophytes is "biomass turnover", or the sloughing off of plant fragments during the growing season. Because this release occurs throughout the growing season, it has a greater potential to influence the growth of algae than the seasonal senescence described below. Defined as annual net production (of a species) divided by the maximum seasonal biomass (of that species), biomass turnover would allow potentially higher levels of nutrient (especially phosphorus) release than senescence. As reported by Carpenter 1980, turnover rates for the larger plants of mesotrophic and euthrophic lakes are generally within the range of 1.0 to 2.6. This means that potentially between 100% and 260% more nutrients could be available for release on an annual basis. Westlake (1975, described in Barko and Smart, 1980) estimated the annual net production of submersed macrophytes to be 1.20 to 1.25 times their seasonal maximum biomass.

Smith and Adams (1986) reported that over the entire year 2.8 g P/m^2 was lost from *M. spicatum* shoots. This was equated to 93% of plant's total annual phosphorus uptake. However, this magnitude of phosphorus release was indicated to be probably greater than that from other aquatic species based on this plants higher relative productivity and unusually high shoot turnover. Also, milfoil shoot fragments are highly buoyant and can remain suspended in the water until most of the original organic content is lost.

M. spicatum is not yet a significant component of the plant community in the portions of Coeur d'Alene Lake addressed in this study. However, Barko et al. (1991) indicate that the effects of aquatic macrophytes on nutrient cycling are most pronounced with the robust submersed species, such as "the large species of *Myriophyllum*, *Elodea* and *Potamogeton*" because these species have high biomass turnover during the growing season. Unfortunately, no specific release rates were presented by Barko et al., or otherwise found for *Elodea* or *Potamogeton*.

For the present study, phosphorus release from sloughed plant fragments in Coeur d'Alene Lake is assumed to be 1.25 times the seasonal maximum phosphorus content for each species for which nutrient content data was measured for this project. This is the high end of the estimate from Westlake (1975) but towards the lower end of that from Carpenter (1980). This also appears to be conservative compared to the 2.8 g P/m^2/year presented by Smith and Adams (1986).

Phosphorus Release from Plant Senescence

In temperate climates, most of the aquatic plant biomass dies (a process known as ‘senescence’) in late summer or fall, some or all of the annual accumulation of biomass is decomposed and nutrients are released (Landers, 1982). By virtually all accounts, this seasonal plant senescence has the greatest potential to provide nutrients from existing plant beds into the open water. However, the process of release, and the influences which mediate this release are extremely complex and experimental results are often conflicting.

The stages of aquatic plant decomposition are fairly predictable, according to a review presented by Barko et al (1991). Decay is first initiated by the liberation of soluble materials (“intracellular cytoplasmic compounds”) such as sugars, fatty acids and amino acids. Soluble forms of nutrients are also released, including phosphorus, nitrogen and several cations (sodium, potassium, calcium and magnesium). Leaching and autolysis (splitting open of plant cells) are responsible for rapid, quantitatively significant losses of nitrogen, phosphorus and potassium from plant tissues. Later loss of plant matter is associated with decomposition of more resistant organic materials such as cellulose and lignin.

A key influence on the potential release of nutrients from decaying plant matter is the proportion of that matter that is resistant to decomposition; the so-called “refractory fraction”. Experiments conducted by Jewel (1971) on a number of aquatic species (including *E. canadensis* and “*Potamogeton* sp.”) resulted in the determination that the refractory fraction varied between 11% and 50% and averaged 24% of the initial organic matter content. Horne and Goldman (1994) indicate 30% as the refractory fraction of phosphorus in the phytoplankton (algae). Jewell further indicates that the quantities of nitrogen and phosphorus regenerated (released) during decay can be predicted within 25% by using the measured refractory fraction and the initial nutrient concentration. From his studies the species-specific refractory fraction for *E. canadensis* was 19.2% and 27.4% (unaltered samples) and that for “*Potamogeton* species” was 19.3% (chopped samples). In these same trials Jewell determined that 78.6% of the phosphorus was released from *Elodea* and 100% of the phosphorus was released from *Potamogeton* sp. (thus the simple refractory fraction approach for these two species appeared to underestimate the actual release slightly).

Using data presented in Nichols and Keeney (1973), Landers (1982) calculated that 27% of the phosphorus and 53% of the nitrogen should remain in decayed *M. spicatum* as a refractory fraction. Landers concluded that approximately 70% of the phosphorus and 50% of the nitrogen present in the plant tissue before senescence would be released to the surrounding water. However, Nichols and Keeney indicate in their 1973 publication that, from their experiments, the presence of sediments in the experimental containers caused “much less” phosphorus to be released due to absorption of dissolved, inorganic phosphorus compounds.

In another laboratory study, this time using *Ceratophyllum demersum*, Best et al (1990) monitored plant decomposition and found that, under aerobic conditions only between 3.1% and

5.7% of the initial total phosphorus content of the plant matter was found in the water; the majority was in the sediments or remaining leaf litter.

Another factor, referred to by several researchers is the time between the onset of senescence and when the plant collapses onto the sediments, at which time nutrient release from the plants to the open water essentially ends (Nichols and Keeney, 1976; Carpenter, 1980). This is undoubtedly affected by many factors, such as temperature and plant species. In Coeur d'Alene Lake the influence of drawdown (which could potentially shorten the time to collapse by removing the water column) is essentially an unquantifiable factor.

For the present study, phosphorus release from seasonal submersed plant senescence in Coeur d'Alene Lake is therefore assumed to be 50% of the measured phosphorus content.

Phosphorus Release from Epiphyton

A potentially significant influence on phosphorus or nitrogen that might be released by macrophytes (during active growth sloughing or senescence) is that of epiphyton (attached algae and other micro-organisms). Calignan and Kalff (1982) studied the contribution of nine species of macrophyte to the phosphorus nutrition of their epiphyton and found that the epiphytes derived less than 10% of their phosphorus from the supporting macrophytes. Thus epiphytes obtain most of their phosphorus from the open water. This study also found that very little phosphorus would be transferred directly from the macrophytes to the surrounding waters; instead it would be released indirectly via epiphyte metabolism. This infers another, perhaps relatively minor, error in the attempt to perform a simple calculation of nutrient release from macrophytes.

For the present study, phosphorus release from epiphyton is considered an un-quantified factor.

Nitrogen Release

The literature search performed for this project obtained little usable information on the release of nitrogen from macrophytes, especially during active growth. Nichols and Keeney (1973) found that nitrogen tends to be retained or accumulated on particulate macrophyte matter and that release of dissolved nitrogen forms (such as ammonium and nitrate) is minimal. Nichols and Keeney also indicated that nitrogen is required in the decay process, assumably by the organisms that contribute to this decay. The idea that a refractory fraction of plant biomass will limit nutrient release in general is likely pertinent to this analysis, however, it appears from the analysis above regarding phosphorus release that there are other more restrictive limitations to this. Jewel (1971) reported that no release of nitrogen resulted from the senescence or sloughing of *Potamogeton* species while release from *E. canadensis* was between 42.8 and 64.5%. Best et al. (1990) followed plant decomposition of *C. demersum* and found that between 3.0 and 6.8% of the plant's nitrogen was released under aerobic conditions.

Given the level of uncertainty surrounding the release of nitrogen from aquatic vegetation, nitrogen release from seasonal submersed plant senescence in Coeur d'Alene Lake is assumed to be 10% of the measured total nitrogen content for all species. Following the discussion above regarding phosphorus release from sloughed plant materials, a rate of 1.0 times the seasonal maximum nitrogen content is assumed for all species.

Estimate of Nutrient Loading from Aquatic Vegetation

Overview

Effects of submersed aquatic macrophytes on nutrient cycling in lakes are most pronounced in shallow areas that support extensive stands of robust submersed species, such as the large species of *Myriophyllum*, *Potamogeton* and *Elodea* (Carpenter, 1980). These species have high biomass turnover during the growing season and therefore recycle nutrients when water temperatures are high and potential effects on plankton production are maximal (Carpenter, 1983). This being said, the estimation of nutrient release from a diverse plant assemblage in a lake the size of Coeur d'Alene is a complex process and involves many assumptions to expand the limited available data.

There are numerous sources of uncertainty, and thus error, in this type of estimation that should be noted. The sampling error is relatively high not because of errors in the sample collection but because of the inherent patchiness of native aquatic vegetation in Coeur d'Alene Lake, and in lakes in general. This is compounded by the expanse of this lake and the variation in bottom slope and substrate, ambient water clarity, aspect, etc. There is also analytical error which potentially affects the results. The lab data reports indicate QC limits of 20% on biomass and nutrient analyses but review of the QC data indicates that this actual error is minimal (less than 5%). There is an obvious error in using averaged biomass and nutrient concentrations and extrapolating these across wide areas. The use of averages was deemed necessary given the somewhat limited time available to complete the data analysis and project report. However, perhaps the greatest uncertainty in this analysis is in the nutrient release criteria. As was indicated, it was hoped to obtain species-specific phosphorus and nitrogen release factors to be used in the loading calculations. As was indicated above, the only species-specific value that was found was for the release of phosphorus during the growth of Elodea, and that was provided by only one study. Further literature search and review might help refine the estimate produced but it appears that the needed information is simply not available.

In spite of the expressed error factors, this author believes that the estimates produced for this project are sound and reasonable. Support for this conclusion comes from a comparison of the estimated nutrient loading from aquatic vegetation with that from other sources described by Woods and Beckwith, 1997 (see Lake-wide Nutrient Loading section below).

Aquatic Plant Growth Regions

Areas of aquatic plant growth were grouped for this analysis into areas (regions) represented by the sampled transects. A description of location and area of these regions is presented in Table 11. The surface area of each region was developed from Avista bathymetry, as corrected by Tribal GIS staff. Basically, a series of polygons were manually drawn in ArcMap over the contour intervals where plants were found (as indicated by the reference transects) in each established region and the areas of the polygons were totaled.

Table 11. Coeur d'Alene Lake Aquatic vegetation regions established for nutrient loading analysis.

CDA LAKE Aquatic Vegetation Region	Representative Transect	Area (m^2)	Description of Aquatic Vegetation Regions
NIC/City Beaches	1	48,159	Entrance to Spokane River east to CDA Resort.
Tubbs Hill	(none)	(not determined) *	
North Shore	2	335,901	CDA Resort east to Sanders Beach.
Blue Creek Bay	3	135,169	Tubbs Hill east to Wolf Lodge Bay region, excluding Blue Creek Bay region.
Wolf Lodge Bay	4	332,663	Interior of bay
Beauty Bay	5	18,616	Interior of bay
New-name Bay	6	210,039	Interior of bay
Arrow Point	(none)	(not determined) *	Both sides of point
Echo Bay	7	55,039	Interior of bay
NE Shore	8	(not determined) *	Wolf Lodge region west and south to Carlin Bay Region, excluding Beauty Bay,
			New-name Bay, Arrow Point and Echo Bay regions.
Carlin Bay	9	97,128	Interior of bay
Mid-E Shore	10	(not determined) *	Carlin Bay region south to Harrison Slough region
Harrisoon Slough	CDAR-1	2,158,669	Entire bay area
Harrison Bay	CDAR-2	535,418	Entire bay area
SE Shore	11	111,697	Harrison Bay region south to south side Ogara Bay
South End	12	681,515	South side Ogara Bay to Lower Lakes Project Boundary.
SW Shore	15	121,410	Lower Lakes Project Boundary north to Windy Bay, excluding Carey Bay and
			3-Bays region.
Carey Bay	13	66,370	Interior of bay
Cottonwood Bay	14	11,736	Interior of bay
3-Bays	16	32,376	Interior of 16-to-1, Cave and Aberdeen bays.
Windy Bay	17	206,397	Interior of bay
Mid-West Shore	19 & 20	636,593	Windy Bay north to Mica Bay, excluding Rockford Bay and Lofts Bay regions.
Rockford Bay	18	76,893	Interior of bay
Lofts Bay	21	52,611	Interior of bay
Mica Bay	22	231,893	Interior of bay
NW Shore	23 & 24	363,420	Mica Bay region north to Cougar Bay, excluding Kidd Island Bay region.
Kidd Island Bay	25	220,156	Interior of bay
Cougar Bay	26 & 27	1,283,708	Entire bay area to entrance to Spokane River (including Blackwell Island slough).

* areas not determined because there was not representative transect or because there was no vegetatoin found on the representative transect.

Calculation of Nutrient Pool Available for Potential Release

Data from the Coeur d'Alene Lake aquatic vegetation regions, including species biomass and calculated nutrient pool and nutrient release is presented in Table D1 in Appendix D. Nutrient pool is calculated starting with the sum of all biomass values for each species (for which nutrient data was available, see Tables 7-10) for all depths within each transect. This sum is divided by the number of depths that that had any plants present in that transect to average out the biomass of each species over the transect (if certain depths were sampled more than once, i.e. the b, c, d samples, these were also counted). The result of this is labeled "Adjusted Biomass" and this provides the estimate of biomass for each species in the transect (at least those for which nutrient content was determined). The Adjusted Biomass for each species is multiplied by the total area of the region to determine total biomass. Total biomass is then multiplied by the average nutrient concentrations (TP and TKN, from Tables 7 and 8, respectively) for each species to calculate the "Nutrient Pool" in that growth region. This is the amount of phosphorus and nitrogen that is potentially available for release into the lake.

Nutrient Release Criteria

The following criteria were assumed for the predominant submersed species found in Coeur d'Alene Lake based on the above discussion of the literature search on nutrient release. Phosphorus release from growing plants was assumed to be negligible for all species except *Elodea* which was applied a rate of 25 μg P per gram of dry biomass per day (over a 180 day growing season). Nitrogen release from growing plants was assumed to be negligible for all species. Phosphorus release from sloughed plant materials (also referred to as "turnover") was assumed to be 1.25 times the average phosphorus concentration measured for this study. Nitrogen release from turnover was 1.0 times the average TKN concentration. Phosphorus release from senescing plants was 50 % of the average TP concentration and nitrogen release due to senescence was 10 % of the TKN concentration.

Lake-wide Nutrient Loading Result

The calculated total annual release of phosphorus from the aquatic vegetation in Coeur d'Alene Lake (excluding the Lower Lakes study area) was 5,603 kg (see Table D1). The calculated total annual release of nitrogen was 18,237 kg. The three predominant regions for both phosphorus and nitrogen release were Harrison Slough, Cougar Bay and the South End. The primary reason that is apparent for this predominance is the surface area of the regions as there does not appear to be substantial differences in the species present or their respective densities.

The calculated nutrient loading is not inconsistent with historical loading from a variety of sources. The best comparable information is the nutrient budgets presented by Woods and Beckwith in their 1997 report. Table 12, below, is extracted from that report and shows the primary (top five) nutrient loading sources calculated from 1991 and 1992 data. From this it can be seen that the phosphorus loading estimated from the present study of aquatic vegetation is lower than that from all listed sources except Plummer Creek. Nitrogen loading from aquatic

Table 12. Predominant nutrient loading sources to Coeur d'Alene Lake from 1991 and 1992 (from Woods and Beckwith, 1997).

1991	Source	Phosphorus Load (kg)	Nitrogen Load (kg)
	St. Joe River	72,100	1,040,000
	Coeur d'Alene River	22,000	801,000
	Wastewater	19,900	127,000
	Precipitation	6,460	75,000
	Plummer Creek	2,060	38,000
1992	**Source**	**Phosphorus Load (kg)**	**Nitrogen Load (kg)**
	St. Joe River	18,300	418,000
	Wastewater	13,400	85,100
	Coeur d'Alene River	9,980	314,000
	Precipitation	6,460	75,000
	Plummer Creek	1,130	21,900

vegetation is lower than all five sources reported by Woods and Beckwith. Further, comparing the aquatic vegetation loadings with the total loadings for 1991 and 1992 (not including aquatic vegetation, 1991 had 133,000 kg P and 2,270,000 kg N and 1992 had 55,000 kg P and 1,020,000 kg N) yields 4% of the P load and 0.8% of the N load for 1991 and 10% of the P load and 2% of the N load for 1992. Even considering that the 2005 aquatic vegetation calculations do not include the Lower Lakes area, and may be underestimated by the pre-maximum biomass period sampling, the estimate of nutrient loading is considered reasonable.

Conclusions and Recommendations

The overall conclusion offered from this baseline assessment of submersed aquatic vegetation in Coeur d'Alene Lake is that this growth is healthy, very productive in certain areas (primarily the bays) and moderately diverse. The plants that were identified in the Coeur d'Alene Lake transects were all native species with the exception of *Myriophyllum spicatum* which was only found in three transects in the southern portion of the lake. Given the extensive growth of this species in the adjacent Lower Lakes area (particularly Chatcolet and Round Lakes), it is expected that this presence in Coeur d'Alene Lake proper will increase significantly in the coming years, absent implementation of control measures.

The two dominant species found, on a biomass basis, were *Potamogeon amplifolius* and *P. robbinsii*, both robust pondweed species. On the basis of frequency of occurrence, however, the groups "*Elodea* species" (primarily *E. canadensis*) and "*Potamogeton* species" (the thin-leafed pondweeds) were dominant. Other species which were found to be prevalent included *Ceratophyllum demersum*, *Isoete*s sp., *P. richardsonii*, *Ranunculus aquaticus* and *Sagitaria* sp. The macroalgae *Chara* and *Nitella* were also seen fairly frequently. Submersed species were found typically at the three to 21-foot depths, with few sites having plant growth to the 24 or 27 foot depth. The highest level of biomass (on a lake-wide basis) was found at the 12 foot depth.

Mean biomass levels (dry weight) of the submersed species, where found, ranged from greater than 60 g/m^2 for *P. amplifolius* and *P. robbinsii*, to slightly over 1 g/m^2 for the smaller species *Isoetes* and *Nyad* sp. Maximum sample biomass values approached or exceeded 300 g/m^2 for *C. demersum*, the group "*Elodea* species", *P. robbinsii* and the group "*Potamogeton* species". The biomass data compiled by transect (all species and depths) indicated that Cougar Bay had the highest overall density of submersed vegetation, at 68 g/m^2. Blue Creek Bay, Echo Bay and the south end of Coeur d'Alene Lake all had average biomass over 40 g/m^2. These higher-biomass areas, and in fact most areas supporting submersed plants at all, had soft, organic muck sediments. There were only three of the 29 transects that were found to have no vegetation and these were steeply sloping, open shoreline areas with predominantly rocky substrate.

The assemblages of submersed species were reasonably consistent around the lake. Across various depths there was most often only two or three species or species groups seen. By far the most prevalent assemblage was the group *Elodea* species with the group *Potamogeton* species and *P. richardsonii*. The species most often found alone was *P. amplifolius*.

Nutrient (phosphorus and nitrogen) analysis data from the seven predominant plant species was used with the biomass data and aquatic vegetation regions to develop an estimate of potential nutrient loading to the lake from the existing plant communities. This estimate could be incorporated into water quality modeling programs to provide additional understanding of the lake's nutrient budget. The analyses that plant samples from this study were submitted to were total phosphorus, total Kjeldahl nitrogen, nitrate nitrogen and nitrite nitrogen. Of these the total phosphorus and total Kjeldahl nitrogen were the most significant.

Elodea species were found to contain the highest concentration of phosphorus, with a mean of 4,738 µg P/g. *Ceratophyllum demersum* and *Potamogeton* species also averaged over 4,000 µg P/g. The lowest mean phosphorus concentration of the plants analyzed was 2,975 µg P/g in *P. robinsii*. The maximum single total phosphorus concentration reported was 6,050 µg P/g, again in *Elodea* species, while the lowest single value was 2,180 µg P/g in *P. richardsonii*.

The highest mean total Kjeldahl nitrogen concentration found was 25,457 µg N/g with the group *Potamogeton* species and the lowest, 21,000 µg N/g, was with *P. amplifolius*. The maximum single value found was 27,400 µg N/g with *Potamogeton* species and the minimum was 13,600 with *Elodea* species.

The estimation of nutrient release from the aquatic plants in Coeur d'Alene Lake was a key part of this project and literature values were used in this estimate. Phosphorus release from growing plants was assumed to be negligible for all species except *Elodea* which was applied a rate of 25 µg P per gram of dry biomass per day (over a 180 day growing season). Nitrogen release from growing plants was assumed to be negligible for all species. Phosphorus release from sloughed plant materials (also referred to as “turnover”) was assumed to be 1.25 times the average phosphorus concentration of the plants. Nitrogen release from turnover was 1.0 times the average total Kjeldahl nitrogen concentration. Phosphorus release from senescing plants was 50 % of the average total phosphorus concentration and nitrogen release due to senescence was 10 % of the total Kjeldahl nitrogen concentration.

The nutrient release criteria were applied to calculated total phosphorus and total nitrogen pool values to achieve the estimate of phosphorus and nitrogen release from the plants into the waters of Coeur d’Alene Lake. The nutrient pools were determined from an adjusted total biomass for each species (for which nitrogen or phosphorus was measured) in each of a series of aquatic vegetation regions which were represented by the sampled transects. The resulting total biomass values were multiplied by the average phosphorus and nitrogen contents to achieve the values for the phosphorus and nitrogen pools.

The calculated total annual release of phosphorus from the aquatic vegetation in Coeur d’Alene Lake (excluding the Lower Lakes study area) was 5,603 kg. The calculated total annual release of nitrogen was 18,237 kg. These loadings were found to be consistent with historical loading from a variety of sources, amounting to between 4% and 10% of other phosphorus load sources and between 0.8% and 2% of other nitrogen load sources. Phosphorus and nitrogen loading estimated from the present study were lower than that from the two major tributaries (the Coeur d’Alene and St. Joe Rivers), from wastewater and from precipitation.

Periodic re-surveys should be performed to monitor changes in the submersed plant communities and to help refine the understanding of biomass and nutrient pool distributions. To improve the estimate of nutrient loading to the lake from the aquatic vegetation it would be helpful to survey additional transects, especially in the open shoreline areas.

The results of the Lower Lakes Aquatic Vegetation Survey project, which followed identical protocols to those of the present project, should be combined so that a more complete picture of aquatic plant growth and potential impacts on lake water quality can be considered by the lake managers.

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Appendix A. Field and Laboratory Data

Table A1. Aquatic vegetation biomass data collected for the Baseline Coeur d'Alene Lake Survey, 2005.

Date Sampled	Transect	Depth (ft)	Substrate	Species Code	Dry wt. (g)	Biomass (g/m2)
7/12/05	1	0	sandy	(no veg)		
		3	sandy	(no veg)		
		6	sandy w/ bark	Psp	0.1	0.48
		9	sandy w/ bark	(no veg)		
7/12/05	2	0	rocky	(no veg)		
		3	rocky	(no veg)		
		6	rocky	(no veg)		
		9	rocky	Iso	0.23	1.10
				RA	1.01	4.83
		12	rocky	RA	2.33	11.15
		15	rocky w/ muck	Esp	0.14	0.67
				PR	6.68	31.96
				Psp	0.07	0.33
				RA	ND	0.01
		18	muck	PRi	3.78	18.09
				PR	28.9	138.28
				RA	0.18	0.86
		21	muck	PR	21.1	100.96
				Psp	4.52	21.63
		24	muck	PR	3.62	17.32
				Psp	7.19	34.40
		27	muck	Psp	1.58	7.56
7/13/05	3	0	muck	(emerg only)		
		3	muck	Cha	6.43	30.77
				Esp	0.14	0.67
				Iso	0.04	0.19
				Nsp	0.18	0.86
				PRi	7.2	34.45
				Psp	0.48	2.30
		6	muck	Esp	sack mislabeled? No data	
				PRi	1.39	6.65
				Psp	45.1	215.79
		9	muck	Esp	68.9	329.67
				Psp	0.72	3.44
				RA	0.25	1.20
						page 1 of 12

Table A1 (continued).

Date Sampled	Transect	Depth (ft)	Substrate	Species Code	Dry wt. (g)	Biomass (g/m2)
7/13/05	3	12	muck	PA	16.7	79.90
		15	muck	PA	9.21	44.07
		18	muck	Nit	0.65	3.11
7/13/05	4	0	muck	(no veg)		
		3	muck	Cha	ND	0.01
				Psp	0.04	0.19
		3b	muck	Esp	2.29	10.96
				PRi	5.77	27.61
				Psp	4.41	21.10
		6	muck	PRi	3.39	16.22
				Psp	1.65	7.89
		9	muck	Iso	0.08	0.38
				PA	1.21	5.79
				Psp	0.41	1.96
		12	muck	Esp	ND	0.01
				PA	34.9	166.99
		15	muck	PA	30.7	146.89
7/13/05	5	0	rocky	(no veg)		
		3	rocky	(no veg)		
		6	muck	Psp	0.42	2.01
		9	muck	Esp	0.46	2.20
				PA	8.12	38.85
				PR	0.11	0.53
				RA	0.22	1.05
		12	muck	PA	19.7	94.26
		15	muck	PR	4.4	21.05
		18	muck	Cha	0.1	0.48
				PR	2.87	13.73
7/12/05	6	0	muck	(emerg only)		
		3	muck	Esp	0.61	2.92
				Psp	21.9	104.78
				Ssp	0.41	1.96
		6	muck	Esp	5.65	27.03
				Nsp	0.28	1.34
				PRi	5.76	27.56
				Psp	2.1	10.05
		9	muck	Esp	ND	0.01
				Nit	0.28	1.34
				PA	5.44	26.03
				PR	7.59	36.32
				RA	1.20	5.74
						page 2 of 12

Table A1 (continued).

Date Sampled	Transect	Depth (ft)	Substrate	Species Code	Dry wt. (g)	Biomass (g/m2)
7/12/05	6	12	muck	PA	39.9	190.91
				PR	31.5	150.72
		15	muck	PA	29.1	139.23
				PR	0.38	1.82
		18	muck	Esp	0.26	1.24
				Nit	0.38	1.82
				PA	5.22	24.98
				PR	9.45	45.22
				Psp	0.53	2.54
		21	muck	Psp	5.36	25.65
		24	muck	Psp	0.56	2.68
7/13/05	7	0	muck	(emerg only)		
		3	muck	Cha	6.05	28.95
				Esp	1.69	8.09
				Psp	3.4	16.27
		6	muck	Esp	1.65	7.89
				Nit	5.29	25.31
				Psp	6.35	30.38
				Ssp	1.87	8.95
		9	muck	PA	9.16	43.83
				PR	35.1	167.94
				PRi	12	57.42
				Psp	0.16	0.77
		12	muck	PA	3.27	15.65
				PR	68.8	329.19
		15	muck	Nit	0.03	0.14
				PA	22.1	105.74
				PR	13	62.20
				PRi	2.16	10.33
				Psp	ND	0.01
		18	muck	PR	24.9	119.14
				Psp	2.07	9.90
		21	muck	Nit	5.03	24.07
				Psp	1.83	8.76
7/14/05	8	0	rocky/stony	(terrest. only)		
		3	rocky	(no veg)		
		6	rocky	(no veg)		
		9	rocky	(no veg)		
		12	rocky	(no veg)		
		15	rocky w/ muck	(no veg)		
		18	muck	(no veg)		
		21	muck	(no veg)		
						page 3 of 12

Table A1 (continued).

Date Sampled	Transect	Depth (ft)	Substrate	Species Code	Dry wt. (g)	Biomass (g/m2)
7/14/05	9	0	rocky	(no veg)		
		3	muck	Cha	1.54	7.37
				PRi	12.2	58.37
				Psp	1.22	5.84
				Ssp	0.63	3.01
		6	muck	Cha	0.28	1.34
				Esp	0.18	0.86
				Nit	0.38	1.82
				PRi	5.57	26.65
				Psp	6.78	32.44
				Ssp	0.41	1.96
		9	muck	PR	35.7	170.81
				PRi	2.17	10.38
				Psp	0.15	0.72
		12	muck	PR	43.4	207.66
		15	muck	PA	2.70	12.92
		18	muck	Esp	0.38	1.82
				Nit	0.01	0.05
				PR	12	57.42
				Psp	0.12	0.57
7/7/05	10	0	rocky	(no veg)		
		3	rocky	(no veg)		
		6	rocky	(no veg)		
		9	rocky	(no veg)		
		12	rocky	(no veg)		
		15	rocky	(no veg)		
		18	rocky	(no veg)		
		21	rocky	(no veg)		
6/30/05	11	0	rocky	(no veg)		
	note:	3	rocky	(no veg)		
	used	6	rocky	(no veg)		
	sampler	9	rocky	Msp	0.77	3.90
	A	12	rocky	PF	1.22	6.18
	this	15	rocky	PR	1.26	6.38
	transect	18	rocky	(no veg)		
6/21/05	12	0	rocky	(no veg)		
		3	rocky	(no veg)		
		6	rocky	(no veg)		
		9	muck	Esp	5.51	26.36
				Nit	1.18	5.65
				Psp	22.1	105.74
						page 4 of 12

Table A1 (continued).

Date Sampled	Transect	Depth (ft)	Substrate	Species Code	Dry wt. (g)	Biomass (g/m2)
6/21/05	12	12	muck	Esp	4.9	23.44
				Psp	3.28	15.69
		15	muck	(too sparce to sample)		
		15b	muck	CD	9.4	44.98
		12b	muck	CD	0.75	3.59
				Esp	1.1	5.26
		9b	muck	CD	62.6	299.52
				Esp	9.76	46.70
				VA	0.57	2.73
		9c	muck	CD	0.68	3.25
				Esp	69.3	331.58
				Msp	8.64	41.34
				PRi	4.55	21.77
		12c	muck	Esp	1.26	6.03
				Msp	6.96	33.30
				Nit	0.5	2.39
		15c	muck	CD	2.22	10.62
				Esp	0.5	2.39
				Msp	0.67	3.21
				Nit	0.34	1.63
		15d	muck	CD	3.7	17.70
				Esp	0.61	2.92
		12d	muck	CD	51.4	245.93
				Esp	0.66	3.16
				Msp	3.62	17.32
				RA	0.4	1.91
		9d	muck	CD	1.86	8.90
				Esp	39.00	186.60
				Msp	6.4	30.62
		12e	muck	Esp	10.9	52.15
				PR	1.06	5.07
6/30/05	13	0	muck	(emerg only)		
		3	muck	Esp	1.18	5.65
				Psp	9.05	43.30
				Ssp	1.83	8.76
		6	muck	Esp	13.6	65.07
				Psp	8.43	40.33
		9	muck	Esp	16.6	79.43
				Psp	0.68	3.25
				RA	1.87	8.95
						page 5 of 12

Table A1 (continued).

Date Sampled	Transect	Depth (ft)	Substrate	Species Code	Dry wt. (g)	Biomass (g/m2)
6/30/05	13	12	muck	Esp	1.93	9.23
				Psp	0.65	3.11
				PZ	3.01	14.40
				RA	0.34	1.63
		15	muck	Psp	1.19	5.69
		18	muck	Esp	0.43	2.06
				Psp	0.43	2.06
		21	muck	Psp	0.36	1.72
6/30/05	14	0	rocky	(no veg)		
		3	rocky	(no veg)		
		6	rocky w/ silt	Esp	0.46	2.20
				PRi	0.92	4.40
				Ssp	0.61	2.92
		9	muck	Esp	0.64	3.06
				PRi	3.21	15.36
				PZ	0.79	3.78
				Ssp	0.59	2.82
		12	muck	Esp	7.52	35.98
				Psp	1.85	8.85
		15	muck	Esp	6.45	30.86
				Psp	2.86	13.68
		18	muck	Esp	0.35	1.67
				Psp	1.98	9.47
				PRi	0.51	2.44
		21	muck	Esp	0.25	1.20
				Psp	0.89	4.26
7/7/05	15	0	rocky	(no veg)		
		3	rocky	(no veg)		
		6	rocky	(no veg)		
		9	rocky	Esp	0.52	2.49
				Iso	0.22	1.05
				PRi	0.23	1.10
				RA	0.55	2.63
		12	rocky	Esp	1.02	4.88
		15	rocky	Esp	0.24	1.15
				Psp	0.03	0.14
7/7/05	16	0	rocky	(no veg)		
		3	rocky	(no veg)		
		6	sandy	Esp	1.9	9.09
				Psp	7.18	34.35
						page 6 of 12

Table A1 (continued).

Date Sampled	Transect	Depth (ft)	Substrate	Species Code	Dry wt. (g)	Biomass (g/m2)
7/7/05	16	6b	muck	Esp	0.98	4.69
				Iso	0.13	0.62
				PRi	2.25	10.77
				RA	5.41	25.89
		9	muck	Esp	1.77	8.47
				Nit	0.61	2.92
				PRi	2.58	12.34
				Psp	0.67	3.21
				RA	0.35	1.67
		12	muck	Esp	4.91	23.49
				Nit	0.2	0.96
				PRi	2.93	14.02
		15	muck	Esp	13.3	63.64
				PRi	3.64	17.42
				Psp	7.88	37.70
				RA	sack mislabeled? No data	
		18	muck	Esp	0.9	4.31
				Nit	0.64	3.06
				Psp	7.14	34.16
		21	muck	Psp	3.01	14.40
7/7/05	17	0	muck	(emerg only)		
		3	muck	Esp	0.34	1.63
				Psp	16.9	80.86
				Ssp	0.47	2.25
		3b	muck	Esp	0.83	3.97
				PRi	29.4	140.67
				Psp	7.67	36.70
				Ssp	0.97	4.64
		6	muck	Esp	3.26	15.60
				PRi	0.89	4.26
				Psp	1.11	5.31
		9	muck	Esp	6.65	31.82
				PRi	2.26	10.81
				Psp	38.1	182.30
		12	muck	Esp	2.53	12.11
				Psp	4.47	21.39
		15	muck	Esp	1.26	6.03
				PF	2.15	10.29
				Psp	1.26	6.03
		18	muck	Esp	0.31	1.48
				PF	1.83	8.76
		21	muck	Esp	0.34	1.63
						page 7 of 12

Table A1 (continued).

Date Sampled	Transect	Depth (ft)	Substrate	Species Code	Dry wt. (g)	Biomass (g/m2)
7/7/05	18	0	muck	(emerg only)		
		3	muck	Cha	1.5	7.18
				Esp	1.04	4.98
				Iso	0.52	2.49
				Psp	8.86	42.39
				Ssp	3.13	14.98
				UNK	2.99	14.31
		3b	muck	Cha	1.91	9.14
				Esp	0.5	2.39
				PRi	6.87	32.87
				Psp	16.6	79.43
				Ssp	1.95	9.33
		6	muck	Esp	24.2	115.79
				Nit	2.51	12.01
				PRi	7.54	36.08
				Psp	8.2	39.23
		9	muck	Esp	0.65	3.11
				Nit	0.56	2.68
				PRi	16.00	76.56
		12	muck	PF	7.66	36.65
				PRi	8.35	39.95
		15	muck	Nit	0.23	1.10
				PF	0.68	3.25
				Psp	0.04	0.19
		18	muck	Nit	3.98	19.04
				Psp	0.98	4.69
7/7/05	19	0	stony	(no veg)		
		3	stony	(no veg)		
		6	muck	Ssp	0.82	3.92
		6b	muck	Esp	1.00	4.78
				Nit	0.45	2.15
				PA	9.05	43.30
				Psp	0.32	1.53
				RA	0.34	1.63
		9	muck	Esp	0.10	0.48
				Iso	0.82	3.92
				Nit	0.54	2.58
		12	muck	Nit	0.91	4.35
				PA	4.43	21.20
				PR	1.86	8.90
				RA	0.81	3.88
						page 8 of 12

Table A1 (continued).

Date Sampled	Transect	Depth (ft)	Substrate	Species Code	Dry wt. (g)	Biomass (g/m2)
7/7/05	19	15	muck	Nit	0.67	3.21
				PA	4.89	23.40
				PRi	4.73	22.63
		18	muck	Psp	16.8	80.38
		21	muck	Esp	0.15	0.72
				Nit	0.7	3.35
				Psp	7.73	36.99
7/14/05	20	0	gravelly	(terrest only)		
		3	rocky	(no veg)		
		6	rocky	(no veg)		
		9	rocky	(no veg)		
		12	rocky	(no veg)		
		15	rocky	(no veg)		
		18	rocky	(no veg)		
		21	rocky	(no veg)		
		24	rocky	(no veg)		
		27	rocky	(no veg)		
7/14/05	21	0	gravelly	(terrest only)		
		3	muck	Cha	0.22	1.05
				PRi	1.45	6.94
				Psp	11.1	53.11
				Ssp	0.62	2.97
				UNK	0.07	0.33
		6	muck	PRi	14.2	67.94
				Psp	1.24	5.93
		9	muck	Cha	0.09	0.43
				Esp	3.06	14.64
				Nit	0.09	0.43
				PRi	2.78	13.30
		12	muck	Esp	20.5	98.09
				Psp	0.73	3.49
		15	muck	Esp	7.87	37.66
				Psp	5.27	25.22
		18	muck	Esp	5.55	26.56
				Psp	14.6	69.86
		21	muck	CD	0.65	3.11
				Nit	0.46	2.20
				Psp	0.04	0.19
		24	muck	Nit	0.37	1.77
7/14/05	22	0	gravelly	(no veg)		
		3	muck	Esp	0.21	1.00
				Psp	31.4	150.24
						page 9 of 12

Table A1 (continued).

Date Sampled	Transect	Depth (ft)	Substrate	Species Code	Dry wt. (g)	Biomass (g/m2)
7/14/05	22	6	muck	Esp	4.99	23.88
				Psp	0.28	1.34
		9	muck	CD	1.95	9.33
				Esp	13.3	63.64
				PRi	1.18	5.65
				Psp	6.58	31.48
				RA	0.18	0.86
		12	muck	CD	1.03	4.93
				Esp	12.00	57.42
				PR	1.78	8.52
				PRi	3.89	18.61
				Psp	1.43	6.84
		15	muck	CD	3.34	15.98
				Esp	1.53	7.32
				PRi	0.67	3.21
				Psp	5.82	27.85
		18	muck	CD	4.84	23.16
				Psp	2.48	11.87
		21	muck	CD	3.6	17.22
				Nit	ND	0.01
				PR	3.72	17.80
		24	muck	CD	0.05	0.24
				Psp	0.03	0.14
7/14/05	23	0	rocky	(no veg)		
		3	rocky	(no veg)		
		6	rocky	(no veg)		
		9	rocky	(no veg)		
		12	rocky	(no veg)		
		15	rocky	Esp	0.2	0.96
		18	rocky	(no veg)		
		21	rocky	(no veg)		
7/11/05	24	0	rocky	(no veg)		
		3	rocky	(no veg)		
		6	rocky	Esp	0.18	0.86
				PRi	0.25	1.20
				Psp	0.18	0.86
		9	rocky	PR	1.19	5.69
				RA	2.48	11.87
		12	rocky	PR	1.22	5.84
				RA	0.16	0.77
		15	rocky	PR	0.82	3.92
				RA	0.64	3.06
						page 10 of 12

Table A1 (continued).

Date Sampled	Transect	Depth (ft)	Substrate	Species Code	Dry wt. (g)	Biomass (g/m2)
7/11/05	25	0	muck	(emerg only)		
		3	muck	Esp	0.09	0.43
				Psp	14.2	67.94
		6	muck	Esp	4.13	19.76
				PRi	9.18	43.92
				Psp	8.75	41.87
		9	muck	Esp	0.65	3.11
				Nit	0.03	0.14
				PA	10.8	51.67
				Psp	0.84	4.02
		12	muck	PA	15.3	73.21
				PR	sack mislabeled? No data	
		15	muck	PR	5.51	26.36
				PRi	0.18	0.86
7/11/05	26	0	muck	(emerg only)		
		3	muck	Esp	1.06	5.07
				Psp	26.0	124.40
				UNK	0.39	1.87
		5	muck	Esp	37.6	179.90
				Nit	0.43	2.06
				Psp	19.7	94.26
		note: no access past log boom to sample deeper				
7/11/05	27	0	muck	(emerg only)		
		3	clay w/ gravel	(no veg)		
		6	muck	Esp	14.7	70.33
				Iso	ND	0.01
				Nit	0.42	2.01
				Psp	5.3	25.36
				RA	0.57	2.73
		note: no access past log boom to sample deeper				
7/5/05	CDAR-1	0	?	(emerg only)		
		3	muck	(emerg only)		
		4	muck	PR	9.48	45.36
				PZ	0.55	2.63
		4b	muck	Psp	59.6	285.17
		4c	muck	Esp	2.23	10.67
				Psp	9.43	45.12
				VA	4.83	23.11
		6	muck	Nit	17.3	82.78
				VA	1.35	6.46
		5	muck	CD	0.54	2.58
				PF	9.31	44.55
						page 11 of 12

Table A1 (continued).

Date Sampled	Transect	Depth (ft)	Substrate	Species Code	Dry wt. (g)	Biomass (g/m2)
7/5/05	CDAR-1	5	muck	Psp	4.67	22.34
				PZ	1.53	7.32
		6b	muck	Esp	0.41	1.96
				Msp	0.57	2.73
				PA	6.55	31.34
				PR	10.3	49.28
		9	muck	(no veg)		
		8	muck	CD	7.7	36.84
				PF	0.86	4.11
				PR	27.5	131.58
				PRi	9.97	47.70
		9b	muck	PR	0.36	1.72
				Psp	2.2	10.53
		12	muck	Psp	2.21	10.57
		15	muck	(no veg)		
		18	muck	(no veg)		
		21	muck	(no veg)		
7/5/05	CDAR-2	0	muck	(no veg)		
		3	muck	Nit	3.52	16.84
				PRi	16.8	80.38
				Psp	0.26	1.24
		6	muck/clay	Esp	0.45	2.15
				Nit	1.79	8.56
				PRi	1.18	5.65
				Psp	1.36	6.51
		9	muck/clay	Esp	0.59	2.82
				PRi	6.67	31.91
				Psp	5.61	26.84
		12	muck	Psp	34.2	163.64
		15	muck	Psp	29.1	139.23
		18	muck	Esp	0.43	2.06
				Psp	10.2	48.80
		21	muck	(no veg)		
						page 12 of 12

Table A2. Aquatic vegetation nutrient data (phosphorus and nitrogen compounds) collected for the Baseline Coeur d'Alene Lake Survey, 2005.

Date Sampled	Transect	Depth (ft)	Species Code	TP (µg P/g)	TKN (µg N/g)	NO3 (µg N/g)	NO2 (µg N/g)
7/12/05	2	18	PR	2,600	19,500	38.2	< 0.5
7/13/05	3	3	PRi	3,180	22,300	3.9	< 0.5
7/13/05	3	6	Psp	3,640	23,600	3.4	< 0.5
7/13/05	3	9	Esp	3,650	19,400	4.1	< 0.5
7/13/05	3	15	PA	5,500	23,800	4.3	< 0.5
7/12/05	6	12	PA	4,150	23,900	7.2	< 0.5
7/12/05	6	12	PR	2,980	25,700	< 0.5	< 0.5
7/12/05	6	15	PA	3,580	22,900	0.70	< 0.5
7/13/05	7	9	Psp	4,500	22,000	9.8	< 0.5
7/13/05	7	15	PA	2,450	19,300	29.3	< 0.5
7/13/05	7	15	PR	2,600	21,500	28.8	11.8
7/14/05	9	3	PRi	3,900	22,600	4.6	1.50
7/14/05	9	6	PRi	2,180	14,800	2.6	< 0.5
7/14/05	9	12	PR	4,330	26,400	21.5	< 0.5
6/21/05	12	9	Psp	4,670	27,000	13.8	< 0.5
6/21/05	12	9b	CD	5,200	22,800	15.6	< 0.5
6/21/05	12	9c	Esp	3,080	13,600	1.0	< 0.5
6/21/05	12	12d	CD	3,610	23,200	31.4	< 0.5
7/7/05	17	3b	PRi	5,300	26,200	20.2	< 0.5
7/7/05	18	6	Esp	5,640	25,000	6.8	< 0.5
7/7/05	18	6	PRi	4,030	24,000	12.4	< 0.5
7/7/05	18	12	PRi	5,540	26,200	202	< 0.5
7/7/05	19	6b	PA	2,510	14,100	26.8	< 0.5
7/14/05	22	3	Psp	4,970	27,400	9.6	< 0.5
7/14/05	22	9	Esp	6,060	26,500	3.3	< 0.5
7/14/05	22	18	CD	5,200	23,400	39.1	< 0.5
7/11/05	25	12	PA	3,140	22,000	77.6	< 0.5
7/11/05	26	3	Psp	4,560	26,600	1.6	< 0.5
7/11/05	26	5	Esp	5,260	24,800	3.0	< 0.5
7/5/05	CDAR-1	4b	Psp	3,540	24,700	12.2	< 0.5
7/5/05	CDAR-1	5	PF	3,120	26,000	25.0	5.8
7/5/05	CDAR-1	6b	PR	2,780	25,600	36.4	3.0
7/5/05	CDAR-1	8	PR	2,560	25,500	54.2	< 0.5
7/5/05	CDAR-2	3	PRi	3,210	22,100	21.6	< 0.5
7/5/05	CDAR-2	9	PRi	4,420	23,800	15.8	< 0.5
7/5/05	CDAR-2	18	Psp	4,430	26,900	1.5	< 0.5

Appendix B. Quality Control Results

Table B1. Laboratory Quality Control results for Baseline Coeur d'Alene Lake Aquatic Vegetation Survey; duplicate biomass samples.

Lab ID #	Sample Number	METHOD	ORIGINAL RESULT (g)	DUPLICATE RESULT (g)*	Relative % Difference	Notes
5071101-07	12-12 Esp	Mod SM10400	4.90	4.91	0.20	
5071102-01	12-12d CD	Mod SM10400	51.4	51.7	0.58	
5071103-09	12-15b CD	Mod SM10400	9.40	9.28	1.28	
5071104-07	13-9 RA	Mod SM10400	1.87	1.97	5.21	
5071105-01	13-6 Esp	Mod SM10400	13.6	13.8	1.46	
5071106-06	14-9 Pri	Mod SM10400	3.21	2.99	7.10	
5071107-01	13-3 Esp	Mod SM10400	1.18	1.2	1.68	
5071108-02	CDAR1-8 VA	Mod SM10400	1.35	1.44	6.45	
5071109-09	CDAR1-4c Esp	Mod SM10400	2.23	2.17	2.73	
5071110-10	CDAR1-4 PR	Mod SM10400	9.48	9.51	0.32	
5071903-07	18-12 Pri	Mod SM10400	8.35	8.44	1.07	
5071904-04	19-9 Esp	Mod SM10400	0.10	0.05	66.7	QR-01
5071905-03	16-18 Psp	Mod SM10400	7.14	7.05	1.27	
5071906-09	17-6 Pri	Mod SM10400	0.89	0.81	9.41	
5071907-09	15-9 Iso	Mod SM10400	0.22	0.23	4.44	
5071908-01	16-12 Pri	Mod SM10400	2.93	2.74	6.7	
5071909-05	18-3b Pri	Mod SM10400	6.87	6.82	0.73	
5072002-03	16-15 Psp	Mod SM10400	7.88	7.73	1.92	
5072003-02	17-6 Psp	Mod SM10400	1.11	1.01	9.43	
5072004-04	18-9 Esp	Mod SM10400	0.65	0.64	1.55	
5072005-03	25-3 Psp	Mod SM10400	14.2	14.3	0.70	
5072501-05	6-6 Esp	Mod SM10400	5.65	5.62	0.53	
5072502-06	6-9 Nit	Mod SM10400	0.28	0.24	15.4	
5072503-07	2-9 RA	Mod SM10400	1.01	0.93	8.25	
5072504-02	26-5 Psp	Mod SM10400	19.7	19.6	0.51	
5072505-08	25-15 PR	Mod SM10400	5.51	5.51	0	
5072506-04	2-15 PR	Mod SM10400	6.68	6.65	0.45	
5072507-07	5-9 PA	Mod SM10400	8.12	8.1	0.25	
5072508-09	7-9 Psp	Mod SM10400	0.16	0.13	20.7	QR-01
5072703-05	3-12 PA	Mod SM10400	16.7	16.6	0.60	
5072704-08	21-3 UNK	Mod SM10400	0.07	0.12	52.6	QR-01
5072705-08	22-9 CD	Mod SM10400	1.95	1.98	1.53	
5072706-04	22-9 Pri	Mod SM10400	1.18	1.14	3.45	
5072707-03	21-9 Psp	Mod SM10400	4.75	4.6	3.21	
5072708-06	22-9 RA	Mod SM10400	0.18	0.14	25.0	QR-01
5072709-03	4-6 PP	Mod SM10400	3.39	3.3	2.69	
5072710-08	3-3 Iso	Mod SM10400	0.04	0.04	0	
5072711-09	4-9 Iso	Mod SM10400	0.08	0.08	0	
5072712-02	22-24 CD	Mod SM10400	0.05	0.04	22.2	QR-01
5072713-08	21-18 Esp	Mod SM10400	5.55	5.6	0.90	
	Mean RPD for results within RPDCL =				**2.91**	

* All QC samples were re-dried for an additional 20 - 24 hours prior to re-weighing.

QR-01 = Analyses are not controlled on RPD values from sample concentrations less than 10 times the reporting limit. QC batch accepted based on LCS and/or LCSD QC results.

Table B2. Laboratory Quality Control results for Baseline Coeur d'Alene Lake Aquatic Vegetation Survey; duplicate nutrient samples.

LAB ID #	SAMPLE NUMBER	ANALYTE	METHOD	ORIGINAL RESULT	DUPLICATE RESULT	DETECTION LIMIL	REPORT LIMIT	UNITS	SOURCEID	Rel. % Diff.	RPDCL
B5J0302-DUP2	12-9B CD	TP	EPA 365.4	5,200	4,920	1.25	2.5	mg/kg	5071104-01	5.53	25
B5J0302-DUP3	26-5 Esp	TP	EPA 365.4	5,260	5,060	1.25	2.5	mg/kg	5072506-02	3.88	25
B5L0602-DUP1	3-3 PRi	TP	EPA 365.4	3,180	3,180	1.25	2.5	mg/kg	5072710-01	0.00	25
B5J0301-DUP2	12-9B CD	TKN	EPA 351.2	22,800	23,100	15	25	mg/kg	5071104-01	1.31	25
B5J0301-DUP3	26-5 Esp	TKN	EPA 351.2	24,800	24,900	15	25	mg/kg	5072506-02	0.40	25
B5L0601-DUP1	3-3 PRi	TKN	EPA 351.2	22,300	22,700	15	25	mg/kg	5072710-01	1.78	25
B5L0504-DUP1	18-6 PP	Nitrate	EPA 300.0	12.4	11.6	0.5	1.0	mg/kg	5071904-10	6.67	20
B5L0504-DUP2	19-6B PA	Nitrate	EPA 300.0	13.4	12.8	0.5	1.0	mg/kg	5071909-02	4.58	20
B5K1805-DUP1	22-18 CD	Nitrate	EPA 300.0	39.1	38.7	0.5	1.0	mg/kg	5072704-10	1.03	20
B5L0504-DUP1	18-6 PP	Nitrite	EPA 300.0	ND	ND	0.5	1.0	mg/kg	5071904-10	n/a	20
B5L0504-DUP2	19-6B PA	Nitrite	EPA 300.0	ND	ND	0.5	1.0	mg/kg	5071909-02	n/a	20
B5K1805-DUP1	22-18 CD	Nitrite	EPA 300.0	ND	ND	0.5	1.0	mg/kg	5072704-10	n/a	20

Table B3. Laboratory Quality Control results for Baseline Coeur d'Alene Lake Aquatic Vegetation Survey; nutrient matrix spike samples.

LAB ID #	SAMPLE NUMBER	ANALYTE	METHOD	SOURCE RESULT	SPIKE CONC.	SPIKE RESULT	UNITS	RECOVERY (%)	SOURCEID	UPPER CL	LOWER CL
B5J0302-MS2	12-9B CD	TP	EPA 365.4	5,200	1,000	6,060	mg/kg	86	5071104-01	120	80
B5J0302-MS3	26-5 Esp	TP	EPA 365.4	5,260	1,000	6,310	mg/kg	105	5072506-02	120	80
B5L0602-MS1	3-3 PRi	TP	EPA 365.4	3,180	2,000	5,220	mg/kg	102	5072710-01	120	80
B5J0301-MS2	12-9B CD	TKN	EPA 351.2	22,800	2,000	24,900	mg/kg	105	5071104-01	120	80
B5J0301-MS3	26-5 Esp	TKN	EPA 351.2	24,800	1,000	25,700	mg/kg	90	5072506-02	120	80
B5L0601-MS1	3-3 PRi	TKN	EPA 351.2	22,300	5,000	26,400	mg/kg	82	5072710-01	120	80
B5L0504-MS1	18-6 PP	Nitrate	EPA 300.0	12.4	100	92.4	mg/kg	80	5071904-10	120	80
B5L0504-MS2	19-6B PA	Nitrate	EPA 300.0	13.4	100	102	mg/kg	89	5071909-02	120	80
B5K1805-MS1	22-18 CD	Nitrate	EPA 300.0	39.1	100	139	mg/kg	100	5072704-10	120	80
B5L0504-MS1	18-6 PP	Nitrite	EPA 300.0	ND	100	70.0	mg/kg	70.0 *	5071904-10	120	80
B5L0504-MS2	19-6B PA	Nitrite	EPA 300.0	ND	100	76.8	mg/kg	76.8 *	5071909-02	120	80
B5K1805-MS1	22-18 CD	Nitrite	EPA 300.0	ND	100	70.1	mg/kg	70.1*	5072704-10	120	80

* Lab Note QM-01: The spike recovery for this QC sample is outside of established control limits due to sample matrix interference.

Table B4. Laboratory Quality Control results for Baseline Coeur d'Alene Lake Aquatic Vegetation Survey; reference nutrient samples (known nutrient content apple leaves).

LAB ID #	ANALYTE	METHOD	RESULT	REFERENCE LEVEL	UNITS	RECOVERY (%)	UPPER CL	LOWER CL
B5J0302-SRM1	TP	EPA 365.4	1,620	1,590	mg/kg	102%	125%	75%
B5L0602-SRM1	TP	EPA 365.4	1,540	1,590	mg/kg	97%	125%	75%
B5L0602-SRM2	TP	EPA 365.4	1820	1590	mg/kg	114%	125%	75%
B5J0301-SRM1	TKN	EPA 351.2	22,500	23,100	mg/kg	97%	125%	75%
B5L0601-SRM1	TKN	EPA 351.2	20,700	23,100	mg/kg	90%	125%	75%
B5L0601-SRM2	TKN	EPA 351.2	19,600	23,100	mg/kg	85%	125%	75%
B5K1805-SRM1	Nitrate	EPA 300.0	99.8	106	mg/kg	94.2%	122.6	77.4

Table B4. Laboratory Quality Control results for Baseline Coeur d'Alene Lake Aquatic Vegetation Survey; nutrient blank samples.

LAB ID #	ANALYTE	METHOD	RESULT	DETECTION LIMIT	REPORT LIMIT	UNITS
B5J0302-BLK2	TP	EPA 365.4	ND	1.25	2.5	mg/kg
B5J0302-BLK1	TP	EPA 365.4	ND	1.25	2.5	mg/kg
B5L0602-BLK2	TP	EPA 365.4	ND	1.25	2.5	mg/kg
B5L0602-BLK1	TP	EPA 365.4	ND	1.25	2.5	mg/kg
B5J0301-BLK2	TKN	EPA 351.2	ND	15.0	25.0	mg/kg
B5J0301-BLK1	TKN	EPA 351.2	ND	15.0	25.0	mg/kg
B5L0601-BLK2	TKN	EPA 351.2	ND	15.0	25.0	mg/kg
B5L0601-BLK1	TKN	EPA 351.2	ND	15.0	25.0	mg/kg
B5L0504-BLK1	Nitrate	EPA 300.0	ND	0.5	1.0	mg/kg
B5K1805-BLK1	Nitrate	EPA 300.0	ND	0.5	1.0	mg/kg
B5L0504-BLK1	Nitrite	EPA 300.0	ND	0.5	1.0	mg/kg
B5K1805-BLK1	Nitrite	EPA 300.0	ND	0.5	1.0	mg/kg

Table B5. Laboratory Quality Control results for Baseline Coeur d'Alene Lake Aquatic Vegetation Survey; empty sack weights, #8 (red ink).

Sack #	STL Sample ID	Initial Sack Weight	Final Weight (g)		
			1	2	Mean
8 (red)	1	10.46	9.94	9.93	9.94
8 (red)	2	10.36	9.85	9.86	9.86
8 (red)	3	10.55	9.98	10.01	10.00
8 (red)	4	10.48	9.97	9.97	9.97
8 (red)	5	10.52	9.98	9.98	9.98
8 (red)	6	10.53	10	9.97	9.99
8 (red)	7	10.65	10.06	10.06	10.06
8 (red)	8	10.36	9.83	9.84	9.84
8 (red)	9	10.46	9.91	9.92	9.92
8 (red)	10	10.46	9.91	9.91	9.91
8 (red)	11	10.52	9.95	9.95	9.95
8 (red)	12	10.51	9.97	9.98	9.98
8 (red)	13	10.36	9.87	9.86	9.87
8 (red)	14	10.45	9.96	9.96	9.96
8 (red)	16	10.54	10.02	10.02	10.02
8 (red)	17	10.35	9.85	9.85	9.85
8 (red)	18	10.35	9.83	9.86	9.86
8 (red)	19	10.40	9.89	9.90	9.90
8 (red)	20	10.36	9.87	9.87	9.87
8 (red)	21	10.45	9.96	9.96	9.96
				Mean of the means =	**9.93**
				Standard Deviation of the means =	**0.0628**
				Standard deviation of all weights =	**0.0638**

Table B6. Laboratory Quality Control results for Baseline Coeur d'Alene Lake Aquatic Vegetation Survey; empty sack weights, #8 (black ink).

			Final Weight (g)		
Sack #	STL Sample ID	Initial Sack Weight	1	2	Mean
8 (black)	1	10.87	10.29	10.3	10.3
8 (black)	2	10.88	10.32	10.33	10.33
8 (black)	3	10.85	10.29	10.31	10.3
8 (black)	4	10.93	10.38	10.37	10.38
8 (black)	5	10.89	10.3	10.31	10.31
8 (black)	6	10.86	10.31	10.31	10.31
8 (black)	7	10.88	10.3	10.32	10.31
8 (black)	8	10.83	10.28	10.26	10.27
8 (black)	9	10.95	10.37	10.36	10.37
8 (black)	10	10.83	10.25	10.26	10.26
8 (black)	11	10.83	10.27	10.28	10.28
8 (black)	12	10.89	10.34	10.34	10.34
8 (black)	13	10.87	10.29	10.29	10.29
8 (black)	14	10.86	10.29	10.31	10.3
8 (black)	15	10.88	10.29	10.28	10.29
8 (black)	16	10.97	10.36	10.38	10.37
8 (black)	17	10.90	10.31	10.32	10.32
8 (black)	18	10.92	10.35	10.36	10.36
8 (black)	19	10.83	10.29	10.28	10.29
8 (black)	20	10.85	10.27	10.29	10.28
				Mean of the means =	**10.31**
				Standard Deviation of the means =	**0.0350**
				Standard deviation of all weights =	**0.0349**

Table B5. Laboratory Quality Control results for Baseline Coeur d'Alene Lake Aquatic Vegetation Survey; empty sack weights, #420 (black ink).

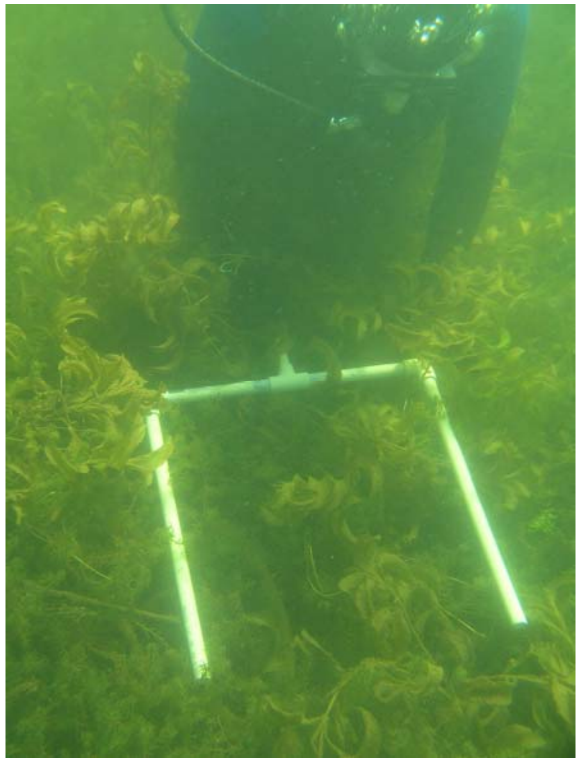
Sack #	STL Sample ID	Initial Sack Weight	Final Weight (g) 1	Final Weight (g) 2	Mean
420	1	20.25	19.13	19.13	19.13
420	2	20.56	19.44	19.44	19.44
420	3	20.49	19.36	19.35	19.36
420	4	20.35	19.25	19.26	19.26
420	5	20.29	19.2	19.2	19.2
420	6	20.47	19.36	19.35	19.36
420	7	20.52	19.37	19.36	19.37
420	8	20.28	19.09	19.09	19.09
420	9	20.21	19.09	19.11	19.1
420	10	20.24	19.21	19.21	19.21
420	11	20.36	19.23	19.24	19.24
420	12	20.26	19.27	19.27	19.27
420	13	20.48	19.32	19.32	19.32
420	14	20.43	19.29	19.29	19.29
420	15	20.54	19.42	19.41	19.42
420	16	20.56	19.41	19.41	19.41
420	17	20.57	19.53	19.53	19.53
420	18	50.59	19.4	19.42	19.41
420	19	20.51	19.37	19.36	19.37
420	20	20.51	19.31	19.31	19.31
				Mean of the means =	**19.30**
				Standard Deviation of the means =	**0.1182**
				Standard deviation of all weights =	**0.1162**

Appendix C. Project Photographs

Photograph 1. Sampling crew preparing for dive at the north end of Coeur d'Alene Lake, 7/14/05.

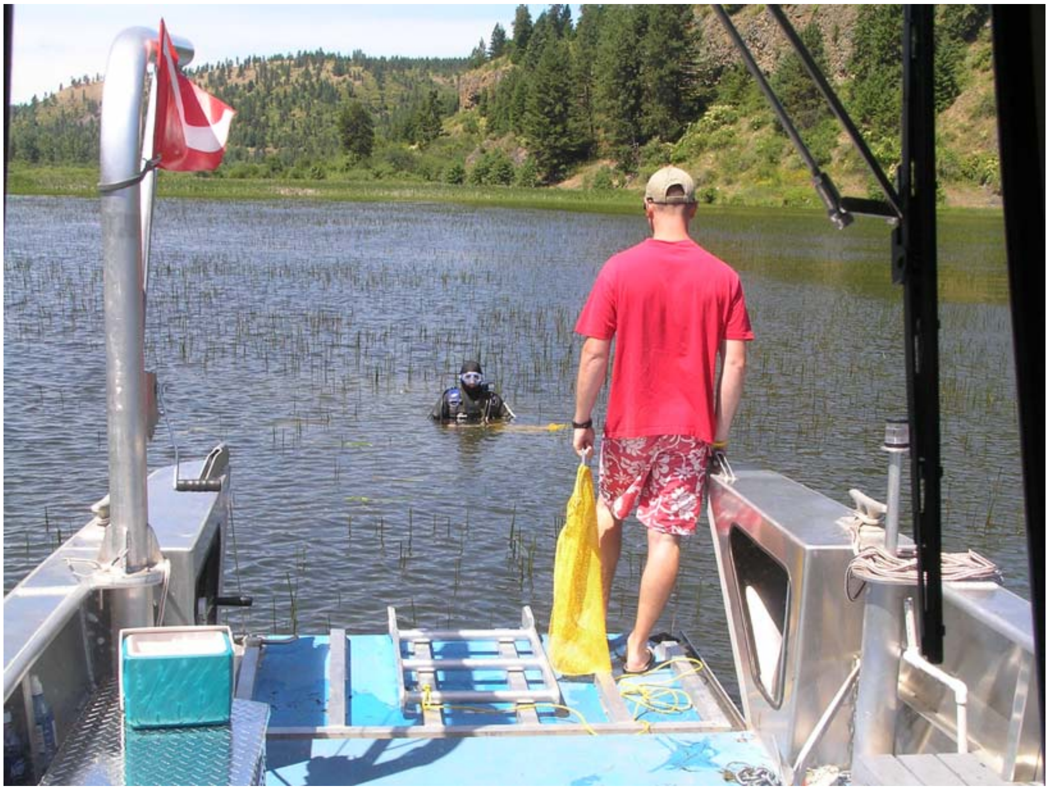
Photograph 2. Sampling crew preparing for dive at Wolf Lodge Bay, Transect 4, 7/13/05.

Photograph 3. Diver delivering sample to boat operator at New-name Bay, Transect 6, 7/12/05.



Photograph 4. Diver with quadrat sampler, Transect 12, 6/21/05.

Photograph 5. Diver preparing to begin transect, Cave Bay, Transect 16, 7/7/05.



Photograph 6. Diver collecting sample in Windy Bay, Transect 17, 7/7/05.

Photograph 7. Diver returning sample to boat in Kidd Island Bay, Transect 25, 7/11/05.

Photograph 8. Diver in Harrison Slough, Transect CDAR-1, 7/5/05.

Appendix D. Nutrient Loading Calculation Spreadsheet

Table D1. Nutrient Loading Calculation Spreadsheet for 2005 Baseline Coeur d'Alene Lake Aquatic Vegetation Survey project. Page 1 of 4.

CDA LAKE Aquatic Vegetation Region	Represent. by Transect #	Species	Adjusted species biomass (g/m^2)*	Vegetation Region Area (m^2)**	Total Biomass (g)	Total P pool (g)	Total N pool (g)	P Released from Active Growth (g/year)	P Released from turnover (g/year)	P released from senescence (g/year)	N Released from Active Growth (g/year)	N Released from turnover (g/year)	N released from senescence (g/year)	TOTAL P RELEASED (g/year)	TOTAL N RELEASED (g/year)
NIC/City Beaches	1	Psp	0.5	48,159	23,116	100	588	0	125	5	0	588	12	130	600
Tubbs Hill	(none)			(not determined)											
North Shore	2	Esp	0.1	335,901	32,151	152	703	145	190	8	0	703	14	343	717
		PR	41.2	335,901	13,844,880	41,189	332,734	0	51,486	2,059	0	332,734	6,655	53,545	339,389
		PRi	9.1	335,901	3,067,256	12,177	69,780	0	15,221	609	0	69,780	1,396	15,830	71,176
		Psp	2.6	335,901	868,064	3,759	22,098	0	4,698	188	0	22,098	442	4,886	22,540
Blue Creek Bay	3	Esp	55.1	135,169	7,441,955	35,260	162,681	33,489	44,075	1,763	0	162,681	3,254	79,327	165,935
		PA	20.7	135,169	2,792,817	9,928	58,649	0	12,411	496	0	58,649	1,173	12,907	59,822
		PRi	6.9	135,169	925,908	3,676	21,064	0	4,595	184	0	21,064	421	4,779	21,486
		Psp	36.9	135,169	4,990,665	21,610	127,047	0	27,012	1,080	0	127,047	2,541	28,092	129,588
Wolf Lodge Bay	4	Esp	2.2	332,663	729,863	3,458	15,955	3,284	4,323	173	0	15,955	319	7,780	16,274
		PA	63.9	332,663	21,268,476	75,609	446,638	0	94,512	3,780	0	446,638	8,933	98,292	455,571
		PRi	8.8	332,663	2,916,124	11,577	66,342	0	14,471	579	0	66,342	1,327	15,050	67,669
		Psp	6.2	332,663	2,071,825	8,971	52,742	0	11,214	449	0	52,742	1,055	11,662	53,797
Beauty Bay	5	Esp	0.4	18,616	8,191	39	179	37	49	2	0	179	4	87	183
		PA	26.6	18,616	495,595	1,762	10,407	0	2,202	88	0	10,407	208	2,290	10,616
		PR	7.1	18,616	131,466	391	3,160	0	489	20	0	3,160	63	508	3,223
		Psp	0.4	18,616	7,484	32	191	0	41	2	0	191	4	42	194
New-name Bay	6	Esp	3.9	210,039	819,415	3,882	17,912	3,687	4,853	194	0	17,912	358	8,734	18,271
		PA	47.6	210,039	10,007,046	35,575	210,148	0	44,469	1,779	0	210,148	4,203	46,248	214,351
		PR	29.3	210,039	6,145,479	18,283	147,694	0	22,853	914	0	147,694	2,954	23,768	150,648
		PRi	3.4	210,039	723,584	2,873	16,462	0	3,591	144	0	16,462	329	3,734	16,791
		Psp	18.2	210,039	3,825,073	16,563	97,375	0	20,703	828	0	97,375	1,947	21,531	99,322
Arrow Point	none	??		(not determined)											
Echo Bay	7	Esp	2.3	55,039	125,646	595	2,747	565	744	30	0	2,747	55	1,339	2,802
		PA	23.6	55,039	1,299,078	4,618	27,281	0	5,773	231	0	27,281	546	6,004	27,826
		PR	96.9	55,039	5,334,616	15,870	128,207	0	19,838	794	0	128,207	2,564	20,632	130,771
		PRi	9.7	55,039	532,699	2,115	12,119	0	2,644	106	0	12,119	242	2,749	12,361
		Psp	9.4	55,039	519,647	2,250	13,229	0	2,813	113	0	13,229	265	2,925	13,493
NE Shore	8	(no veg.)		(not determined -- no veg at rep.site so no interval known to calculate area from)											

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** Deterrmined from Avista/CDA Tribe bathymetrey for the depths plants were found at the representative transect.

Table D1 continued. Page 2 of 4.

CDA LAKE Aquatic Vegetation Region	Represent. by Transect #	Species	Adjusted species biomass (g/m^2)	Vegetation Region Area (m^2)	Total Biomass (g)	Total P pool (g)	Total N pool (g)	P Released from Active Growth (g/year)	P Released from turnover (g/year)	P released from senescence (g/year)	N Released from Active Growth (g/year)	N Released from turnover (g/year)	N released from senescence (g/year)	TOTAL P RELEASED (g/year)	TOTAL N RELEASED (g/year)
Carlin Bay	9	Esp	0.4	97,128	43,384	206	948	195	257	10	0	948	19	462	967
		PA	2.2	97,128	209,149	744	4,392	0	929	37	0	4,392	88	967	4,480
		PR	72.6	97,128	7,056,187	20,992	169,581	0	26,240	1,050	0	169,581	3,392	27,290	172,973
		PRi	15.9	97,128	1,544,497	6,132	35,137	0	7,665	307	0	35,137	703	7,971	35,840
		Psp	6.6	97,128	640,559	2,774	16,307	0	3,467	139	0	16,307	326	3,606	16,633
Mid-E Shore	10	(no veg.)		(not determined -- no veg at rep.site so no interval known to calculate area from)											
Harrisoon Slough	CDAR-1	Esp	2.1	2,158,669	4,543,998	21,529	99,332	20,448	26,912	1,076	0	99,332	1,987	48,436	101,318
		PA	5.2	2,158,669	11,275,448	40,084	236,784	0	50,105	2,004	0	236,784	4,736	52,109	241,520
		PF	8.1	2,158,669	17,506,806	54,621	455,177	0	68,277	2,731	0	455,177	9,104	71,008	464,280
		PR	38.0	2,158,669	82,007,835	243,973	1,970,894	0	304,967	12,199	0	1,970,894	39,418	317,165	2,010,312
		PRi	8.0	2,158,669	17,161,419	68,131	390,422	0	85,164	3,407	0	390,422	7,808	88,570	398,231
		Psp	62.3	2,158,669	134,459,894	582,211	3,422,946	0	727,764	29,111	0	3,422,946	68,459	756,875	3,491,404
Harrison Bay	CDAR-2	Esp	1.2	535,418	627,331	2,972	13,713	2,823	3,715	149	0	13,713	274	6,687	13,988
		PRi	19.7	535,418	10,524,533	41,782	239,433	0	52,228	2,089	0	239,433	4,789	54,317	244,222
		Psp	64.4	535,418	34,469,318	149,252	877,485	0	186,565	7,463	0	877,485	17,550	194,028	895,035
SE Shore	11	PF	2.1	111,697	230,096	718	5,982	0	897	36	0	5,982	120	933	6,102
		PR	2.1	111,697	237,542	707	5,709	0	883	35	0	5,709	114	919	5,823
South End	12	CD	52.9	681,515	36,035,106										
		Esp	57.2	681,515	38,994,017	184,754	852,409	175,473	230,942	9,238	0	852,409	17,048	415,653	869,457
		PR	0.4	681,515	287,940	857	6,920	0	1,071	43	0	6,920	138	1,114	7,058
		PRi	1.8	681,515	1,236,382	4,908	28,128	0	6,136	245	0	28,128	563	6,381	28,690
		Psp	10.1	681,515	6,896,932	29,864	175,575	0	37,330	1,493	0	175,575	3,512	38,823	179,087
SW Shore	15	Esp	2.8	121,410	344,804	1,634	7,537	1,552	2,042	82	0	7,537	151	3,675	7,688
		PRi	0.4	121,410	44,517	177	1,013		221	9	0	1,013	20	230	1,033
		Psp	0.0	121,410	5,666	25	144		31	1	0	144	3	32	147
Carey Bay	13	Esp	23.1	66,370	1,530,682	7,252	33,461	6,888	9,065	363	0	33,461	669	16,316	34,130
		Psp	14.2	66,370	943,118	4,084	24,009	0	5,105	204	0	24,009	480	5,309	24,489
Cottonwood Bay	14	Esp	12.5	11,736	146,661	695	3,206	660	869	35	0	3,206	64	1,563	3,270
		PRi	3.7	11,736	43,423	172	988	0	215	9	0	988	20	224	1,008
		Psp	6.0	11,736	70,944	307	1,806	0	384	15	0	1,806	36	399	1,842

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** Deterrmined from Avista/CDA Tribe bathymetrey for the depths plants were found at the representative transect.

Table D1 continued. Page 3 of 4.

CDA LAKE Aquatic Vegetation Region	Represent. by Transect #	Species	Adjusted species biomass (g/m^2)	Vegetation Region Area (m^2)	Total Biomass (g)	Total P pool (g)	Total N pool (g)	P Released from Active Growth (g/year)	P Released from turnover (g/year)	P released from senescence (g/year)	N Released from Active Growth (g/year)	N Released from turnover (g/year)	N released from senescence (g/year)	TOTAL P RELEASED (g/year)	TOTAL N RELEASED (g/year)
3-Bays	16	Esp	16.2	32,376	525,786	2,491	11,494	2,366	3,114	125	0	11,494	230	5,605	11,724
		PRi	7.8	32,376	252,302	1,002	5,740	0	1,252	50	0	5,740	115	1,302	5,855
		Psp	17.7	32,376	572,731	2,480	14,580	0	3,100	124	0	14,580	292	3,224	14,872
Windy Bay	17	Esp	10.6	206,397	2,189,577	10,374	47,864	9,853	12,968	519	0	47,864	957	23,340	48,821
		PF	2.7	206,397	561,400	1,752	14,596	0	2,189	88	0	14,596	292	2,277	14,888
		PRi	22.2	206,397	4,592,038	18,230	104,469	0	22,788	912	0	104,469	2,089	23,700	106,558
		Psp	47.5	206,397	9,806,216	42,461	249,637	0	53,076	2,123	0	249,637	4,993	55,199	254,630
Mid-West Shore	19	Esp	1.0	636,593											
		PA	14.6	636,593											
		PR	2.4	636,593											
		PRi	3.8	636,593											
		Psp	19.8	636,593											
Mid-West Shore	20	(no veg.)		(not determined -- no veg at rep.site so no interval known to calculate area from)											
Mid-West Shore MEAN	19/20	Esp	0.5	636,593	317,236	1,503	6,935	1,428	1,879	75	0	6,935	139	3,382	7,073
		PA	7.3	636,593	4,662,513	16,575	97,913	0	20,719	829	0	97,913	1,958	21,548	99,871
		PR	1.2	636,593	759,137	2,258	18,244	0	2,823	113	0	18,244	365	2,936	18,609
		PRi	1.9	636,593	1,200,508	4,766	27,312	0	5,958	238	0	27,312	546	6,196	27,858
		Psp	9.9	636,593	6,307,576	27,312	160,572	0	34,140	1,366	0	160,572	3,211	35,505	163,783
Rockford Bay	18	Esp	21.0	76,893	1,618,213	7,667	35,374	7,282	9,584	383	0	35,374	707	17,249	36,082
		PF	6.7	76,893	511,338	1,595	13,295	0	1,994	80	0	13,295	266	2,074	13,561
		PR	2.4	76,893	183,390	546	4,407	0	682	27	0	4,407	88	709	4,496
		PRi	30.9	76,893	2,376,634	9,435	54,068	0	11,794	472	0	54,068	1,081	12,266	55,150
		Psp	27.7	76,893	2,126,476	9,208	54,134	0	11,510	460	0	54,134	1,083	11,970	55,216
Lofts Bay	21	CD	0.4	52,611	20,453										
		Esp	22.1	52,611	1,163,624	5,513	25,437	5,236	6,892	276	0	25,437	509	12,404	25,946
		PRi	11.0	52,611	579,905	2,302	13,193	0	2,878	115	0	13,193	264	2,993	13,457
		Psp	19.7	52,611	1,037,752	4,493	26,418	0	5,617	225	0	26,418	528	5,842	26,946

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Table D1 continued. Page 4 of 4.

CDA LAKE Aquatic Vegetation Region	Represent. by Transect #	Species	Adjusted species biomass (g/m^2)	Vegetation Region Area (m^2)	Total Biomass (g)	Total P pool (g)	Total N pool (g)	P Released from Active Growth (g/year)	P Released from turnover (g/year)	P released from senescence (g/year)	N Released from Active Growth (g/year)	N Released from turnover (g/year)	N released from senescence (g/year)	TOTAL P RELEASED (g/year)	TOTAL N RELEASED (g/year)
Mica Bay	22	CD	8.9	231,893	2,053,992										
		Esp	19.2	231,893	4,442,200	21,047	97,106	19,990	26,309	1,052	0	97,106	1,942	47,351	99,049
		PR	3.3	231,893	762,928	2,270	18,335	0	2,837	113	0	18,335	367	2,951	18,702
		PRi	3.4	231,893	795,973	3,160	18,108	0	3,950	158	0	18,108	362	4,108	18,471
		Psp	28.7	231,893	6,659,967	28,838	169,543	0	36,047	1,442	0	169,543	3,391	37,489	172,934
NW Shore	23	Esp	1.0	363,420											
NW Shore	24	Esp	0.2	363,420											
		PR	3.9	363,420											
		PRi	0.3	363,420											
		Psp	0.2	363,420											
NW Shore MEAN	23/24	Esp	0.6	363,420	214,418	1,016	4,687	956	1,270	51	0	4,687	94	2,286	4,781
		PR	1.9	363,420	701,401	2,087	16,857	0	2,608	104	0	16,857	337	2,713	17,194
		PRi	0.2	363,420	54,513	216	1,240	0	271	11	0	1,240	25	281	1,265
		Psp	0.1	363,420	39,976	173	1,018	0	216	9	0	1,018	20	225	1,038
Kidd Island Bay	25	Esp	4.7	220,156	1,025,927	4,861	22,427	4,617	6,076	243	0	22,427	449	10,936	22,875
		PA	25.0	220,156	5,498,616	19,548	115,471	0	24,434	977	0	115,471	2,309	25,412	117,780
		PR	5.3	220,156	1,160,662	3,453	27,894	0	4,316	173	0	27,894	558	4,489	28,452
		PRi	9.0	220,156	1,971,717	7,828	44,857	0	9,785	391	0	44,857	897	10,176	45,754
		Psp	22.8	220,156	5,012,071	21,702	127,592	0	27,128	1,085	0	127,592	2,552	28,213	130,144
Cougar Bay	26	Esp	92.5	1,283,708											
		Psp	109.3	1,283,708											
Cougar Bay	27	Esp	35.2	1,283,708											
		Psp	12.7	1,283,708											
Cougar Bay MEAN	26/27	Esp	63.8	1,283,708	81,939,082	388,227	1,791,188	368,726	485,284	19,411	0	1,791,188	35,824	873,421	1,827,012
		Psp	61.0	1,283,708	78,319,025	339,121	1,993,767	0	423,902	16,956	0	1,993,767	39,875	440,858	2,033,643
TOTALS =					732,083,578	2,819,382	16,579,346	669,709	3,524,227	140,969	0	16,579,346	331,587	4,334,905	16,910,932

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